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DEVELOPMENT OF TECHNIQUES FOR MULTI-PURPOSE MANAGEMENT OF REUSABLE WATER BEFORE IT ENTERS THE GREAT SALT LAKE

Don M. Rees, et al

Utah University
Salt Lake City, Utah

March 1965

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UNIVERSITY OF UTAH
INSTITUTE OF ENVIRONMENTAL BIOLOGICAL RESEARCH
SALT LAKE CITY, UTAH 84112
COOPERATIVE RESEARCH PROJECT

Annual Report No. 3
1964

MULTIPURPOSE MANAGEMENT OF REUSABLE WATER

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NIH RESEARCH GRANT NUMBER WP-00027-03
TASK FORCE PROJECT V
ANNUAL REPORT NO. 3

DECEMBER 1, 1963 TO NOVEMBER 30, 1964
RELEASED MARCH, 1965

TITLE

DEVELOPMENT OF TECHNIQUES FOR MULTI-PURPOSE MANAGEMENT OF REUSABLE WATER BEFORE IT ENTERS THE GREAT SALT LAKE

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Details of illustrations in
this document may be better
studied on microfiche.

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FOREWORD

In 1960 representatives from eleven federal governmental agencies concerned with soil and water management practices were organized into a "Task Force for Cooperative Research, Field Tests, and Demonstrations on Soil and Water Management Practices." This Task Force functions under the Subcommittee on Vector Control of the Interagency Committee on Water Resources. The stated objectives of this Task Force are to: (1) "develop plans for cooperative research that can be carried out with existing resources of the agencies concerned, and (2) develop plans for cooperative field tests and demonstrations which would be of mutual benefit to the various interests concerned with soil and water management."

Project V, selected as one of seven projects by which the second objective could be accomplished, was described as the "Development of multi-purpose management techniques for waste irrigation water in the Great Salt Lake Basin." An NIH Research Grant, WP-00027, made funds available to the Principal Investigators on September 1, 1961, to conduct a four-year continuation project to develop techniques for multipurpose management of this water. This was to be accomplished with the assistance of personnel from agencies interested in this problem and willing to serve as collaborators. Personnel of collaborating agencies are listed on the following pages.

This project has been in operation for three years and plans for the fourth year have been prepared. All major objectives of the project have been included in the operating program and all collaborating agencies and other participants have taken an active part in establishing and developing these objectives.

A list of publications reporting on this program is presented on page 138.

TABLE OF CONTENTS

Page

Foreword ii
List of tables v
List of figures. vii
General introduction:
  Personnel. 1
  Collaborating agencies and designated representatives. 1
  Others participating 2
  Acknowledgments. 3
  Map of study areas 4

PART I
SUMMARY OF ANNUAL REPORT NO. 3

Summary. 5

PART II
ANNUAL REPORT NO. 3

I. Introduction 9
  A. Title of project 9
  B. Objective. 9
  C. Review of literature 10
II. Mosquito production. 11
  A. Sampling procedures. 11
    1. Larvae 11
    2. Adults 12
  B. Results. 13
    1. Larvae 13
    2. Adults 14
  C. Factors influencing mosquito production. 16
    1. Collection methods 16
    2. Water. 16
    3. Vegetation 19
    4. Climatic conditions. 21
    5. Other factors. 21
III. Wildlife production. 22
  A. Birds. 22
    1. Kinds. 22
    2. Numbers. 22
    3. Factors influencing waterfowl production 23
      a. Water. 23
      b. Vegetation 23
      c. Weather. 24
      d. Disease. 24
  B. Other wildlife 25
    1. Muskrats 25
    2. Fish 25
    3. Reptiles and amphibians. 25

IV. Interrelationships of mosquito control and wildlife management. 26
V. Water 28
  A. Quality 28
    1. Biochemical oxygen demand (BOD) 28
    2. Bacteriological determinations (MPN). 29
    3. Salinity. 29
    4. Miscellaneous 30
  B. Quantity. 30
VI. Weather 32
  A. Temperature 32
  B. Precipitation 32
VII. Encephalitis surveillance 33
VIII. The biting deerflies and horseflies in the marshes of the Great Salt Lake (Diptera - Tabanidae). 34
IX. Progress on the Wheeler Machinery Company Test Area 35
X. Crops 35
XI. Construction. 36
  A. Proposed Farmington Bay by-pass channel 36
  B. Wheeler Machinery Company Test Area 36
  C. Lake Front Gun, Fur and Reclamation Club. 36
XII. Proposed program outline and recommendations for 1965 37
  A. Mosquito surveys. 37
    1. Adult counts. 37
    2. Larval surveys. 37
  B. Wildlife surveys. 37
  C. Water studies 38
  D. Encephalitis surveillance 38
  E. Weather 38
  F. Crops 38
  G. Land development. 38
  H. Recommendations 39
XIII. Conclusions to date 40
  A. Mosquito control and wildlife management. 40
  B. Mosquito control and irrigation 42
  C. Water 42
  D. Crops 42

PART III

Appendix, 1964 report 43
Reports of collaborators. 113
Selected references 133
Publications on Research Grant WP-00027 138

LIST OF TABLES

Appendix Table No.		Page
1	1964 species of mosquito larvae found in each sampling station	45
2	1964 number of times the larvae of each species were collected at each station	46
3	1964 weekly comparison of the number of each species of mosquito larvae collected in the three study areas. . .	48
4	1964 total mosquito larvae collected in weekly collections, April - October.	50
5	1962-1963-1964 weekly comparison of mosquito larva densities measured in number of larvae per dip, Lake Front Gun, Fur and Reclamation Club.	52
6	1962-1963-1964 weekly comparison of mosquito larva densities measured in number of larvae per dip, Farmington Bay Waterfowl Management Area.	53
7	1962-1963-1964 weekly comparison of mosquito larva densities measured in number of larvae per dip, Wheeler Machinery Company Test Area	55
8	1964 - the number of times mosquito larvae were collected, compared by average number per dip	59
9	1962-1963-1964 comparison of average weekly light trap collections.	61
10	1962-1963-1964 comparison of average weekly light trap collections, three stations combined.	64
11	1962-1963-1964 comparison of average weekly collections of biting mosquitoes: Farmington Bay Waterfowl Management Area. . . . . South Davis Sewage Treatment Plant.	 65 66
12	1962-1963-1964 comparison of average weekly collections of biting mosquitoes at two stations combined	67
13	1964 maximum number of mosquitoes taken in one night in light trap and bite count collections	68
14	1964 summary of all mosquitoes collected.	69
15	1964 waterfowl populations on Farmington Bay Waterfowl Management Area	71
16	1960-1964 number of muskrats trapped on Farmington Bay Waterfowl Management Area	71
17	1964 duck nest densities.	72
18	1962-1963-1964 summary of waterfowl bag checks made on Farmington Bay Waterfowl Management Area.	72
19	Water quality data at four selected sampling stations . .	74
20	Water quality data of effluents at four sewage treatment plants in Davis County.	75
21	1964 electrical conductivity measurements	76
22	1964 water analysis report - Lake Front Gun, Fur and Reclamation Club.	78
23	1964 water analysis report - Wheeler Machinery Company Test Area	79
24	Water analyses of Farmington Bay Waterfowl Management Area.	80

LIST OF TABLES (Continued)

Appendix Table No.		Page
25	Chemical quality data of Jordan River	81
26	Chemical quality of Jordan River below Cudahy Lane. . . .	82
27	Specific conductance data on Jordan River at Cudahy Lane.	83
28	Water analyses of Surplus Canal at Cohen Flume near Salt Lake City, Utah.	84
29	Specific conductance data on Surplus Canal at Cohen Flume	85
30	Definitions of Class "C" and Class "D" waters	86
31	Definitions of classes of water based on sodium hazard and salinity	88
32	Daily discharge in second feet of combined Jordan River and Surplus Canal at Salt Lake City, Utah for the year ending September 30, 1964.	89
33	Daily discharge in second feet of the Jordan River at Salt Lake City, Utah for the year ending September 30, 1964.	90
34	Daily discharge in second feet of the Jordan River below Cudahy Lane near Salt Lake City, Utah for the year ending September 30, 1964	91
35	Daily discharge in second feet of the Surplus Canal at Salt Lake City, Utah for the year ending September 30, 1964.	92
36	Daily discharge in second feet of the Surplus Canal at Cohen Flume near Salt Lake City, Utah for the year ending September 30, 1964	93
37	Daily discharge in second feet of Goggin Drain near Magna, Utah for the year ending September 30, 1964	94
38	Daily discharge in second feet of North Point Canal below Goss Flume at Salt Lake City, Utah for the year ending September 30, 1964	95
39	1963-1964 sewage effluents from Salt Lake City and Davis County.	99
40	Evaporation data from Farmington Bay Weather Station	
	Month: May, 1964.	100
	Month: June, 1964	101
	Month: July, 1964	102
	Month: August, 1964	103

LIST OF FIGURES

Appendix Figure No.		Page
1	Mosquito larvae densities, Lake Front Gun, Fur and Reclamation Club.	57
2	Mosquito larvae densities, Farmington Bay Waterfowl Management Area	58
3	Waterfowl marsh profile	73
4	Average electrical conductivity at selected stations on the Lake Front Gun, Fur and Reclamation Club and the Wheeler Machinery Company Test Area	77
5	1964 daily mean discharge in second feet of Goggin Drain, near Magna, Utah	96
6	1964 daily mean discharge in second feet of North Point Canal below Goss Flume at Salt Lake City.	96
7	1962-1963-1964 daily mean discharge in second feet of Jordan River at 2100 South Street, Salt Lake City	97
8	1964 daily mean discharge in second feet of Jordan River below Cudahy Lane near Salt Lake City, Utah and at 2100 South Street, Salt Lake City, Utah.	97
9	1962-1963-1964 daily mean discharge in second feet of Surplus Canal at Salt Lake City, Utah shown as daily mean per month.	98
10	1964 daily mean discharge in second feet of Surplus Canal at Cohen Flume near Salt Lake City, Utah.	98
11	1963 and 1964 precipitation in inches deviation from normal.	104
12	1964 temperature deviation from normal in F°.	105
13	Field trip to study areas	106
14	Phases of the 1964 multi-purpose water management program.	108
15	Phases of the 1964 multi-purpose water management program (continued).	110

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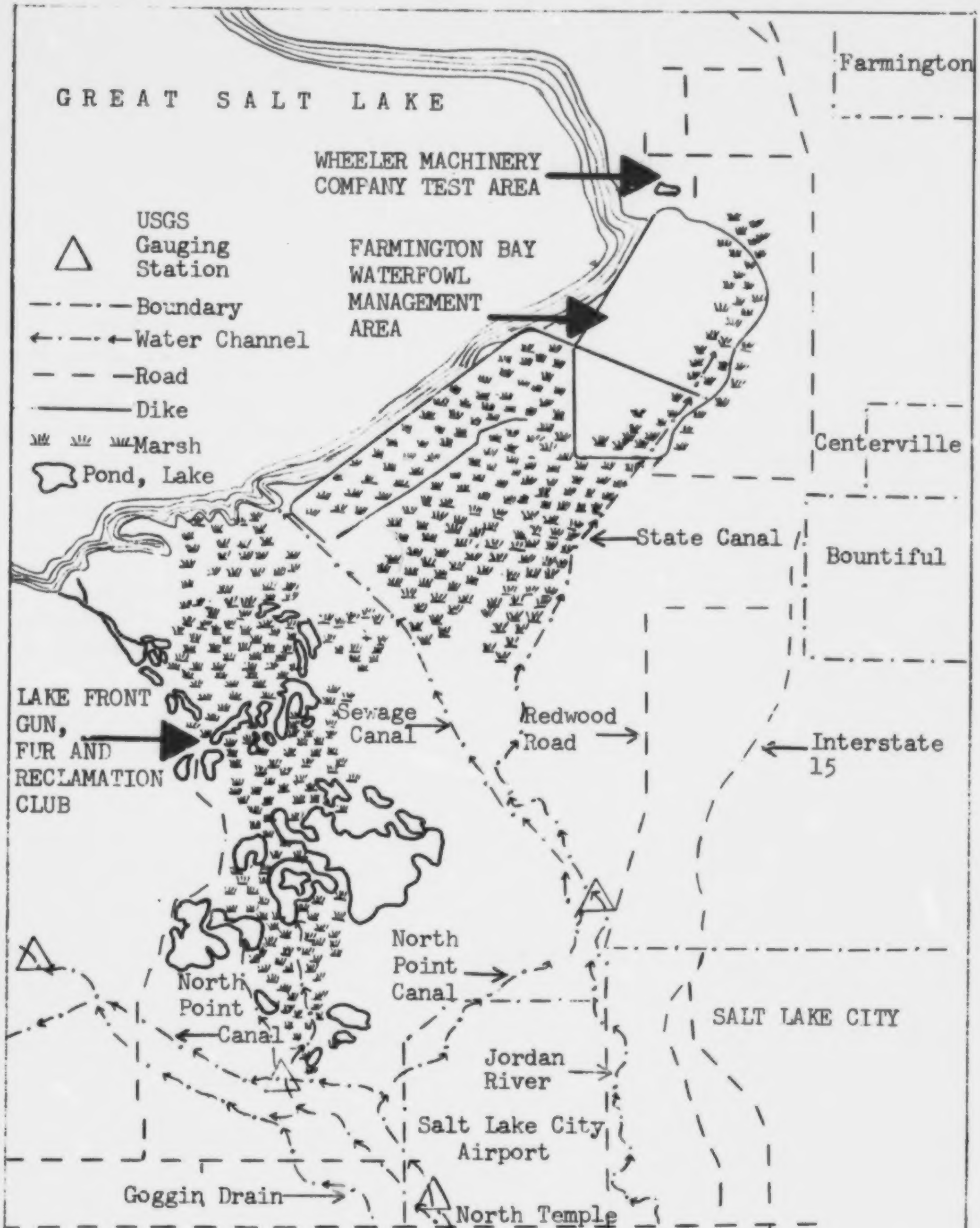
ACKNOWLEDGMENTS

In addition to the financial support received in NIH Research Grant WP-00027 which established this cooperative research program, the numerous collaborating agencies and other participants have made it possible to proceed with the program through their support and active participation. Thanks and appreciation are extended to all participants previously named for their assistance and to the following for their assistance in 1964: The Davis County and Salt Lake City Mosquito Abatement Districts for their cooperation in collecting mosquito samples and assisting in the water management programs in process of development in these districts; the South Davis County Sewage Improvement District for operating, on their property, a light trap for collecting mosquito samples; the faculty and graduate students of the Division of Biological Sciences of the University of Utah who have contributed in numerous ways to this project.

LOCATION OF THE THREE STUDY AREAS



PART I
SUMMARY OF ANNUAL REPORT NO. 3
Covering the Period
December 1, 1963 to November 30, 1964

I. INTRODUCTION

Title of Project:

Development of techniques for multi-purpose management of reusable water before it enters the Great Salt Lake.

Objective:

Since September 1, 1961, an investigation has been in operation to determine the effect of the use of water which eventually flows into the Great Salt Lake upon mosquito production, waterfowl propagation and management, agriculture, recreation, and other programs which are connected with the use of this water. Th

This project is expected to ~~eventually~~ provide demonstration areas that will show how certain kinds of water management practices can: ~~1)~~ minimize the production of pest and disease-bearing mosquitoes, 2) increase crop yields, 3) provide improved conditions for wildlife production and management, and 4) improve beneficial uses of the land and water in ~~this~~ area.

The source of this water is run-off from irrigation, storm gutters and sewers, seepage from canals, discharge from industrial and municipal sewage treatment plants, water from streams originating in the mountains, artesian wells and springs, and other sources. If not checked in its course, this water would flow by the most natural route into the Great Salt Lake.

As the effects of the use of the water are established, an attempt is being made to develop practices for the utilization and management of the water for the maximum benefit to all concerned.

As a part of this water management study, quantitative and qualitative studies are being conducted on the water. Measurements of stream flow are being taken at stream gauging stations in the study area. In addition, discharge rates from sewage treatment plants and pumping stations are being obtained. Water quality is being determined on a basis of biochemical oxygen demand, bacterial analysis, salinity, and alkalinity. Complete ion analysis is also being made and insecticide residue studies are being initiated.

This study was originally planned as a four-year project and is now in the third year. Plans are being formulated to extend this project for another four years.

II. PROCEDURES AND RESULTS

Mosquito Production:

Larval sampling in 1964 was conducted in a manner similar to the sampling procedures used in 1962 and 1963. Seven sampling stations on the Lake Front Gun, Fur and Reclamation Club and eight stations on the Farmington Bay Waterfowl Management Area were maintained and sampled weekly from the third week in April to the middle of October. The number of stations on the Wheeler Test Area was reduced from 19 to 16. These stations were sampled weekly from the first week in April to the middle of October. Six species of mosquitoes were collected in the larval stage in 1964. These are the same species that were collected in 1962 and 1963. Larval densities were lower on most sampling stations in 1964 than in 1962 or 1963.

The adult mosquito population was sampled by means of light traps and biting counts. One species, Anopheles freeborni (Aitken), collected in 1962 and 1963, was not collected in 1964.

Culex tarsalis was the most numerous mosquito taken in light trap collections. Aedes dorsalis was the most numerous mosquito taken on biting count collections. Fewer mosquitoes were collected in light trap samples but more were collected on biting counts in 1964 than in 1962 or 1963. The increase in mosquitoes collected in biting counts was probably the result of numerous Aedes dorsalis being produced in adjacent areas and migrating into the study areas.

Although there was an increased amount of water in the three study areas in 1964, there was a general decrease in the mosquito production over 1962 and 1963. The increased water supply made it possible to fill the marshes and maintain a stable water level in the spring and early summer. As the water supply decreased in the mid-summer months, the water level on the marshes was rapidly drawn down out of the moist soil vegetation areas and again a constant or a slowly decreasing water level was established and maintained. The marshes were reflooded at the end of September or early October just prior to the opening of the waterfowl hunting season. The brood of Aedes dorsalis produced by this late flooding was retarded in development and emerging adults were restricted in their migration and biting activities by the lower temperatures.

Mosquito production on the Wheeler Machinery Company Test Area was reduced through plowing, leveling, and other farming activities.

Wildlife Production:

Nesting surveys and adult bird counts were continued in the study areas. Fewer nests were found in the marsh areas but more nests were found in the upland areas in 1964 as the higher water levels forced the ducks into higher areas for nesting. Fewer ducks and geese were counted in bag checks on the opening weekend of the hunting season in 1964 than in 1962 or 1963. This lower hunter success was attributed to weather and feeding conditions rather than lack of birds.

Interrelationships of Mosquitoes and Wildlife:

A suitable marsh for waterfowl should provide good nesting, feeding, loafing, and cover areas. From the standpoint of mosquito control, a desirable marsh is one which does not produce excessive numbers of mosquitoes. Studies on this project indicate that water management in the marsh areas can be mutually beneficial to mosquito suppression and wildlife management if this management program is developed to meet the multi-purpose objectives of the land and water and if the program is cooperatively formulated and conducted by all persons involved in the use and management of this land and water.

Stabilized water levels, well defined marsh units, and controlled irrigation are beneficial to mosquito control and wildlife management.

Water:

The biological oxidation demand and bacteriological determination sampling programs initiated in 1963 were continued in 1964. Nine water samples were taken weekly to determine salinity. A water sample was collected from each of the nine sampling stations during the months of May, August, and September for complete ion analysis. In addition, stream flow and chemical analysis data were obtained from five gauging stations maintained by the U. S. Geological Survey, Surface Water Branch, on streams entering into the study area.

Because of the high salinity and the sodium hazard, water flowing into the Lake Front Gun Club is of limited agricultural value except for use in growing salt tolerant plants. Endemic plants of value to waterfowl grow abundantly even though the water is of high salinity and low quality. Data gathered indicate that waterfowl propagation is the most practical use of the water because of the saline conditions which exist in the soils adjacent to the Great Salt Lake.

The waters flowing into the Wheeler Machinery Company Test Area are of high quality and no restrictions are placed upon their use in agriculture.

Effluents of the sewage treatment plants in Davis County are considered to have limited beneficial use without additional treatment. It should be noted that three of the plants will have the effluents chlorinated early in 1965. This should result in a considerable improvement in water quality of the effluents from these plants.

The water supply into the study area varies both on a seasonal and on a yearly basis. This variation results from changes in the amount of precipitation and from the varying amounts used by prior water users. This extreme variation in the water supply is a necessary consideration in planning a water management program for mosquito control and waterfowl management.

Planted Crops:

During 1964 selected crops were planted in each of the study areas in conjunction with plans developed by the Soil Conservation Service.

Investigations pertaining to crop plantings in the research areas were partially successful. Information gained during 1964 should insure greater success in the plantings planned for 1965. The salinity of the water and the soil and the method of water application are critical factors in determining the success of crop plantings. Crops which matured were readily utilized by waterfowl and other wildlife.

III. SUMMARY OF CONCLUSIONS TO DATE

1. Water management practices such as water confinement, permanent impoundment, controlled water depth, controlled seasonal and permanent drawdown, and controlled flood irrigation can materially reduce mosquito production.

2. By water management, plants that are desirable for food, nesting, and cover can be greatly increased in number and more widely distributed on the units.

3. Physical facilities such as dikes, channels, drains, access roads, and adequate inlet and outlets are essential for proper water management. Modification of terrain through shore line improvement and deepening of ponds is also necessary in some areas to facilitate water management practices suitable for waterfowl and destructive for mosquitoes.

4. A water management program suited to the multi-purpose objectives of the water on each unit and the requirements necessary to integrate and accomplish these objectives should be formulated by all persons who are concerned with the water and land use in a particular unit.

5. Activities contributing to increased crop production on agricultural land contribute to mosquito reduction.

6. Prior use of the water can impair the water quality and this quality is a limiting factor in the beneficial use of land and water in the study areas.

7. The water supply into the study area varies both on a seasonal and yearly basis and this variation is a necessary consideration in planning any water management program.

8. Water management practices for mosquito control are compatible with approved waterfowl management and agricultural practices.

PART II
ANNUAL REPORT NO. 3
Covering the Period
December 1, 1963 to November 30, 1964

I. INTRODUCTION

A. Title of Project:

Development of techniques for multi-purpose management of reusable water before it enters the Great Salt Lake.

B. Objective:

Since September 1, 1961, an investigation has been in operation to determine the effect of the use of water which eventually runs into the Great Salt Lake, upon mosquito production, waterfowl propagation and management, agriculture, recreation, and other operations which are connected with the use of this water.

This project is expected to eventually provide demonstration areas that will show how certain kinds of water management practices can: 1) minimize the production of pest and disease-bearing mosquitoes, deer-flies and other arthropod pests and disease vectors, 2) increase crop yields, 3) provide improved conditions for wildlife production and management, and 4) improve other beneficial uses of the land and water in this area.

The source of this water is run-off from irrigation, storm gutters, and sewers, seepage from canals, discharge from industrial and municipal sewage treatment plants, water from streams originating in the mountains, artesian wells and springs, and other sources. If not checked in its course, this water would flow by the most natural route into the Great Salt Lake.

As the effects of the use of the water are established, an attempt is being made to develop practices for the utilization and management of the water for the maximum benefit to all concerned.

As a part of this water management study, quantitative and qualitative studies are being conducted on the water. Measurements of stream flow are being taken at stream gauging stations in the study area. In addition, discharge rates from sewage treatment plants and pumping stations are being obtained. Water quality is being determined on a basis of biochemical oxygen demand, bacterial analysis, salinity, and alkalinity. Complete ion analysis is also being made and insecticide residue studies are being initiated.

This study was originally planned as a four-year project and is now in the third year. Plans are being formulated to extend this project for another four years.

C. Review of the Literature:

This review is a supplement to the reviews of literature contained in the 1962 and 1963 Annual Reports which reviewed 14 articles. In addition, the selected references of the 1962 and 1963 Annual Reports contained 104 titles.

Rees, et al. (1964) prepared the 1963 Annual Report on the development of techniques for multi-purpose management of reusable water before it enters the Great Salt Lake. This report included records on mosquito and wildlife production in 1963 and the factors affecting this production in three study areas on the shores of the Great Salt Lake, Utah. It also included the results of qualitative and quantitative water sampling, soils and soil capability, weather, and encephalitis surveillance studies. Recommendations for improved water management practices beneficial to public health, agriculture, fish and wildlife, and other interests were made. This was the second year report of a proposed four-year study.

Springer (1964) discussed ways of satisfying environmental needs of desired wildlife species while encouraging conditions unfavorable for mosquitoes. He discussed physical principles such as impounding, temporary flooding, controlled ditching, and sump drainage. Under biological principles he discussed animal and plant relationships. He emphasized that mosquito control and wildlife management should be compatible and coordinated and should be based on a knowledge of the biology of the species involved and of the ecological factors causing population increase or decrease.

Low, et al. (1964) reported on the activities of the Utah Mosquito Control - Fish and Wildlife Management Coordination Committee in 1963. The objectives of this committee were outlined, the progress in 1963 was reviewed, and a program for 1964 was proposed. This committee was organized in 1962.

Willardson (1964), in discussing water resources development and agriculture, stated that efficiency in the use of water by agriculture is directly related to mosquito production and a high correlation exists between an increase in irrigation efficiency and a decrease in the number of mosquitoes produced. He reported on the "sequential use" or multiple reuse of water beginning with reservoirs and streams in the high mountains and following it down through hydroelectric plants, agricultural, municipal, and industrial uses and finally into the lower areas of the basins where it often forms a habitat for wildlife. He emphasized long-range planning for optimum use of the water resources for all uses by all users.

Hunt (1964) pointed out the role of water resources in recreation development. He stated that while the population will double by the year 2000, demands on water resources are expected to triple. He also pointed out many of the problems involved in the increasing use of our natural resources for recreation. These include fire, vegetation destruction, soil compaction and erosion, and soil and water pollution. He stated that an intensive effort must be made to manage our water and outdoor recreation resources in a compatible manner to provide maximum benefits to our society.

Rees (1964), in commenting on water resource development and use and mosquito control, stated that mosquito production in Utah is largely dependent upon and attributed to water development and use by man. Fifty to eighty percent of the mosquitoes produced during the season in parts of Utah inhabited by man are the result of man-made situations which are created from the development and use of water. He further stated that if mosquito prevention measures were better understood and incorporated into water development plans, mosquito production could not only be reduced but it could be eliminated in many areas with little additional expense and without curtailing water development.

The activities of the National Mosquito Control - Fish and Wildlife Management Coordination Committee have been reported for three years (Springer and Vannnote, 1961; National Committee, 1962; and Quarterman, 1963). This committee arose as an outgrowth of the Symposium on the Coordination of Mosquito Control and Wildlife Management held in Washington, D. C., in 1959. The objectives of this committee and the efforts to realize these objectives have been outlined in these reports.

Ferrigno (1961) wrote on the mosquito-wildlife associations on coastal marshes. He pointed out that mosquito breeding varied in different marshes and that mosquito control recommendations for a marsh should be based on a survey of that particular marsh. He also reported on the relationships between mosquito breeding and vegetational types. The wildlife associations and mosquito problems were also brought out. He stated that cooperation of the different agencies involved is the best approach to the multiple use of our marshlands.

Franz (1963) reported on the production and distribution of mosquito larvae on a series of four salt marsh impoundments in New Jersey. Salinity and pH measurements were included in the study. He stated that vegetation density and water depth fluctuation as well as vegetational type play a role in the production and distribution of mosquito larvae.

A paper by Hoffman and McDuffie (1963) pointed out the mosquito problem and associated livestock losses in Texas. The economic loss resulting from the insect attack on livestock was calculated.

II. MOSQUITO PRODUCTION

A. Sampling Procedures

1. Larvae:

Larval sampling in 1964 was conducted in a manner similar to the sampling procedures used in 1962 and 1963. Seven sampling stations on the Lake Front Gun, Fur and Reclamation Club and eight sampling stations on the Farmington Bay Waterfowl Management Area were maintained during 1964. The number of stations on the Wheeler Test Area was reduced from 19 to 16, Stations 6-B, 7-B, and 15 were not sampled during 1964. The stations on the Wheeler Test Area were sampled once each week from the first of April to the middle of October with a total of 28 samples taken for each station. The stations on the Lake Front Club and Farmington Bay were sampled once each week from the middle of April to the middle of October with a total of 26 samples taken per station.

Samples were taken with a one-pint white enamel dipper. One dip was taken every five paces as the worker moved on a predetermined transect through the sampling station. The total number of larvae and the total number of dips were recorded for each station at each sampling, and from this the average number per dip was determined. Representative samples of the larvae were collected for identification in the laboratory.

2. Adults:

The adult mosquito population was sampled by means of light traps and bite counts similar to those used in 1962 and 1963, and described in Annual Reports numbers 1 and 2. New Jersey type light traps were operated at the Davis County Mosquito Abatement District headquarters at Kaysville, the manager's house at Farmington Bay, and at the north sewage treatment plant of the South Davis County Sewage Improvement District. The Kaysville trap was operated three to four nights a week from the second week in May to the second week in October. The Farmington Bay and South Davis County Sewage Treatment Plant traps were operated two nights a week from the second week in May to the second week in October. The light trap catches were identified, counted, and summarized as average weekly light trap collections. This average was obtained by dividing the total number of mosquitoes collected per week by the total number of collections per week. For comparative purposes, the 1962 and 1963 light trap collections were converted to an average weekly collection. The maximum number of mosquitoes collected per night in each week was also recorded.

Adult biting populations were sampled by means of bite counts taken on Monday and Thursday nights each week from the third week in June to the second week in October. These biting counts were taken at the southeast end of the Farmington Bay Waterfowl Management Area and at the west end of the north plant of the South Davis County Sewage Improvement District. The counts were conducted for one half-hour, commencing 15 minutes after sunset. The collections are summarized as average weekly collections of biting mosquitoes with the average being calculated by dividing the total number of mosquitoes collected per week by the total number of collections made per week. The maximum number of mosquitoes collected per night in each week was also determined.

The results of the larval and adult mosquito collections are summarized in Appendix Tables 1 through 14.

B. Results

1. *Larvae*:

The following species of mosquitoes were found in the larval stages:

Lake Front Club
Aedes dorsalis (Meigen)
Culiseta inornata (Williston)
Culex tarsalis Coquillet
Culex erythrothorax Dyar
Culex salinarius Coquillet

Farmington Bay:
Aedes dorsalis (Meigen)
Culiseta inornata (Williston)
Culex tarsalis Coquillet
Culex erythrothorax Dyar
Culex salinarius Coquillet

Wheeler Test Area:
Aedes dorsalis (Meigen)
Culiseta inornata (Williston)
Culex tarsalis Coquillet
Culex erythrothorax Dyar
Culex pipiens Linnaeus

These are the same species that were found in 1962 and 1963. *Culex erythrothorax*, found on the Lake Front Club in 1962 and 1964, was not found in 1963. *Culex pipiens*, found on Farmington Bay in 1962 and 1963, was not found in 1964. On the Wheeler Test Area, *C. erythrothorax* and C. pipiens were found during 1964 but not in 1963. *Culex salinarius*, which was found on the Wheeler Test Area in 1963, was not found in 1964. *Culex tarsalis* was the most widespread species collected (25 of 31 sampling stations) followed by *Aedes dorsalis* (23 of 31 stations), and *Culiseta inornata* (21 of 31 stations). *Culex erythrothorax* and *C. salinarius* were collected in 3 and *C. pipiens* in 1 of 31 sampling stations. A summary of the species of mosquito larvae collected in each sampling station in the three study areas is shown in Appendix Table 1.

Appendix Table 2 shows the number of times the larvae of each species were collected at each station. This table shows that *C. tarsalis*, followed by *C. inornata* and *A. dorsalis*, was collected most frequently on the Lake Front Club; *C. inornata*, followed by *C. tarsalis* and *A. dorsalis* on Farmington Bay; and *C. tarsalis*, followed by *A. dorsalis* and *C. inornata*, was collected most frequently on the Wheeler Test Area.

In actual numbers of larvae collected, *A. dorsalis*, followed by *C. tarsalis* and *C. inornata*, was the most numerous mosquito collected in the larval stage on the Lake Front Club and the Wheeler Test Area. On Farmington Bay, *C. inornata*, followed by *C. tarsalis* and *A. dorsalis*, was the most numerous mosquito collected. A weekly comparison of the number of each species of larva collected in each of the three study areas is shown in Appendix Table 3.

Appendix Table 4 shows the total number and the percentage of the total number for each species collected in the larval stage from April to October, 1964. The most abundant mosquito collected in the larval stage on the Lake Front Club was *A. dorsalis* in 1963 and 1964. On Farmington Bay, *A. dorsalis*, the most abundant mosquito collected in 1963, was replaced by *C. inornata* in 1964. On the Wheeler Test Area, *C. tarsalis*, the most abundant in 1963, was replaced by *A. dorsalis*, as the most abundant mosquito collected in the larval stage in 1964.

A 1962, 1963, 1964 comparison by week of larval densities as determined by average number per dip in each sampling station is shown in Appendix Tables 5, 6, and 7.

Appendix Figures 1 and 2 show the 1962, 1963, and 1964 seasonal average of larval densities for each of the stations on the Lake Front Club and the Farmington Bay areas. As can be seen from these tables and figures, larval densities were lower in most of the sampling stations in 1964 than in 1962 and 1963. This reduction occurred even though there was more water in these areas in 1964 (Appendix Tables 33-38). The reasons for this reduction will be discussed later in this report. A summary of the number of times larvae were collected in varying densities at each sampling station is presented in Appendix Table 8. A summary of the total number and percent of total of each species collected in the larval stage is presented in Appendix Table 14.

2. *Adults*:

The following species of adult mosquitoes, listed in order of abundance, were collected in light traps in the study area:

Farmington Bay: *Aedes dorsalis*
Culex tarsalis
Culiseta inornata
Culex erythrothorax
Culex pipiens
Aedes nigromaculis (Ludlow)

Anopheles freeborni (Aitken), which was represented by one specimen collected in the Farmington Bay light trap in 1963, was not collected in this trap in 1964. The order of abundance of mosquitoes was the same in 1963 and 1964. In 1962 *C. tarsalis* was the most abundant mosquito taken in this trap. Fewer mosquitoes were taken in this trap than in 1962 or 1963. A 1962, 1963, 1964 comparison of average weekly light trap collections for the Farmington Bay trap is shown in Appendix Table 9.

South Davis County Sewage Treatment Plant:
Culiseta inornata
Culex tarsalis
Aedes dorsalis
Culex erythrothorax
Culex pipiens
Aedes nigromaculis

These are the same species that were collected in this trap in 1962 and 1963. *Culiseta inornata* was the most abundant mosquito collected in this trap in all three years. The total number of mosquitoes collected in 1964 in this trap was lower than 1963 but higher than in 1962. A 1962, 1963, 1964 comparison of average weekly light trap collections for the South Davis Sewage Treatment Plant trap is shown in Appendix Table 9.

Davis County Mosquito Abatement District Headquarters, Kaysville:
Culex tarsalis
Culex pipiens
Culiseta inornata
Aedes dorsalis
Culex erythrothorax

Anopheles freeborni and *Aedes nigromaculis*, collected in 1963, were not collected in 1964. *Culex tarsalis* was the most numerous species collected in this light trap in all three years. The total number of mosquitoes taken in this trap was lower in 1964 than in 1962 and 1963 (see Appendix Table 9).

A 1962, 1963, 1964 comparison of average weekly light trap collections combined is shown in Appendix Table 10. Overall, *C. tarsalis* was the most numerous mosquito taken in light traps followed by *C. inornata* and *A. dorsalis*. *Culex tarsalis* was also the most numerous species collected in 1963. Fewer mosquitoes were taken in light traps in 1964 than in 1962 or 1963. The greatest number in species reduction in comparing 1963 and 1964 was in *A. dorsalis*.

The following adult biting mosquitoes, listed in order of abundance, were collected in 1964:

Farmington Bay: *Aedes dorsalis*
Culex tarsalis
Culiseta inornata
Culex erythrothorax
Culex pipiens

Aedes nigromaculis, collected at this station in 1963, was not collected in 1962 or 1964. *Culex pipiens* was collected both in 1962 and 1964 but not in 1963. Total numbers collected were higher in 1964 than in 1962 or 1963.

South Davis County Sewage Treatment Plant:
Aedes dorsalis
Culex tarsalis
Culiseta inornata
Culex erythrothorax
Culex pipiens
Aedes nigromaculis

These are the same species that were collected in 1963. *Aedes nigromaculis* was not collected from this station in 1962. Total numbers collected were higher in 1964 than in 1962 or 1963.

A 1962, 1963, 1964 comparison of average weekly collections of biting mosquitoes for the two sampling stations is found in Appendix Table 11. A combined summary of the stations is found in Appendix Table 12.

Appendix Table 13 presents the maximum number of mosquitoes taken in any one night of each week in light trap and bite count collections.

Appendix Table 14 presents a summary of all the species of mosquitoes collected in all of the sampling stations.

A discussion of each species of mosquito found in the study area is presented in Annual Report No. 1 (Rees, et al., 1962).

C. Factors Influencing Mosquito Production

1. Collection Methods:

In sampling mosquito populations, fewer mosquitoes were collected in larval samples and light traps but more mosquitoes were collected in biting counts in 1964 than in the two previous years. (See Appendix Tables 1-14 and Appendix Figures 1-2).

Aedes dorsalis accounted for the greatest increase in the number of biting mosquitoes collected. This species was produced in considerable numbers in irrigated pastures adjacent to the study areas. *Aedes dorsalis* can migrate several miles and is a more vicious biter but less attracted to light than other species in this area and is, therefore, more readily taken in biting counts than in light trap collections. This species produced in areas adjacent to the study areas would not be equally reflected in numbers in these two collection methods.

2. Water:

In 1964, in most of the sampling stations of the three study areas, there was a decrease in mosquito production over 1962 and 1963. This decrease in production resulted in spite of an increase in the amount of water present in these areas (Appendix Tables 33-38 and Appendix Figures 5-10). This is contrary to the idea entertained by many people that an increase in the amount of water means an increase in the mosquito problem. In many circumstances the mosquito problem is aggravated more by a lack of water than by an abundance. This is especially true in areas such as many wildlife marshes where complete drainage is neither feasible nor in the best interests of multi-purpose water development and use. The seasonal pattern of the water supply, the area in which the water is used, and the water management program, including physical facilities for water confinement, dispersal, and disposal as well as amount of water, are all important in the analysis of mosquito production.

In comparing the mosquito production as determined by densities of mosquito larvae measured in average number per dip on the Lake Front Gun Club, it can be seen that, with the exception of Sampling Station 7, mosquito production was considerably lower in 1964 than in 1962 or 1963 (Appendix Table 5 and Appendix Figure 1). Appendix Figure 11 indicates the precipitation pattern in inches deviation from normal during 1964. This pattern closely corresponds to the pattern of discharge of water for the Surplus Canal (Appendix Tables 32, 35, 36 and Appendix Figures 9, 10). The Surplus Canal is the source of water supply for several privately owned gun clubs including the Lake Front Club. This water discharge pattern of the Surplus Canal shows a low water flow during the winter months of January, February, and March, with an increase in April, a greater increase in May, and a peak in June. There was a sharp decline in July with lower rates of discharge continuing in August and September. This made it possible to fill the diked marsh units on the Lake Front Club in the early spring and retain the high water level through the early summer. By maintaining constant water levels during this period, only one brood of Aedes dorsalis, the flood water mosquito, was produced in most of the areas. This occurred in the spring following the initial flooding. Because adequate water was available, the water depth of the units was increased thereby decreasing the production of the Culex and Culiseta species, the permanent water mosquitoes. During this time the moist soil plant (salt grass) areas, the emergent marsh (cattail and alkali hardstem, and Olney's bulrush) areas, and the submergent plant (chara, sago pondweed and widgeon grass) areas were kept inundated. In July, as the water supply decreased, the water level in the units was lowered so that only the emergent marsh and the submergent marsh areas were inundated. An attempt was then made to retain this water level or to lower it further during the main mosquito producing months of July, August, and September. On parts of the Lake Front Club units were completely drained to facilitate the building and repair of dikes. The units were again flooded just before the waterfowl hunting season in the middle of October. Another brood of A. dorsalis was produced by this latter flooding but due to low temperatures, the development was slow and the population of emerging adults was reduced and restricted in its migration and biting activities.

An example of the above situation can be seen in Sampling Station 1 on the Lake Front Club. In previous years, this station has been the greatest or one of the greatest mosquito producers on the club. This station consists of a large salt grass field situated on the upper end of an impoundment. There is almost no slope to the ground and the impoundment edge is quite indefinite. Small changes in the water depth have resulted in the flooding or drying of a large part of the salt grass area. A change in one inch in water depth has resulted in the flooding of over 50 linear feet of adjacent area (Rees et al., 1963). During 1964, the water in this area was regulated by means of flash boards in the weirs of the dike so that during the time of high water the salt grass area was kept flooded and during the time of low water this area was kept dry. The above water management practices were successful in measurably decreasing mosquito production in this sampling station. Some minor fluctuations did occur in the pond area with a resultant production of A. dorsalis broods. More careful water management in the future can further reduce mosquito production at this station. A comparison of the mosquito production on this area in 1962, 1963, and 1964 can be seen in Appendix Table 5 and Appendix Figure 1.

To further facilitate the water management on this area, a dike was constructed along the upper end of the impoundment. This dike will serve to retain water in or keep water out of the salt grass area and will allow changes in the water depth of the impoundment without subsequent flooding of the salt grass.

This same type of water management was successful in reducing mosquito production in other sampling stations on the study areas.

Appendix Figure 11 compares the precipitation patterns in 1963 and 1964. The 1963 pattern shows a high in April, a low in May, and another high in June. This low amount of precipitation in May, accompanied by lower discharges in the water supply, allowed many of the marsh areas to become dry. These areas were again flooded in June when the precipitation and the water discharge of the Surplus Canal increased. This flooding produced large numbers of A. dorsalis which moved into the populated areas and were of considerable nuisance during late June and early July in 1963. The lower water supply to the marsh areas contributed to the fluctuations in the water levels and were the result of fluctuations in precipitation.

From the above discussion, it may seem that the water management program for mosquito control is at the mercy of climatic factors and during years of low and fluctuating water supplies an adequate management program cannot be maintained. This is not the case. If the marsh areas are divided into definite relatively small units and the control structures on these units are adequate, during years of low water levels only those units will be maintained for which there is adequate water. The same type of water management program during years of low water availability can be carried out as in years of high water availability except it will be done on a reduced area. Those units for which there is not adequate water could be kept dry or flooded only early and late in the season when the water supply is adequate and, because of the cooler temperatures, mosquitoes do not constitute a problem. The wildlife implications of such a management program will be discussed in a later section.

Mosquito production on Sampling Station 7 on the Lake Front Club increased in 1964 (Appendix Table 5). Most of this increase was the result of one sample taken in the second week of April. Over half the mosquitoes taken from this one station were collected in this one sample. During the remainder of the year the larval population was low for this area.

Mosquito production on Sampling Station 14, Farmington Bay Waterfowl Management Area, was higher in 1964 than 1963. This station is permanently flooded during the entire mosquito season and the mosquitoes collected are all of the permanent water species (Culex and Culiseta spp.). Most of the mosquitoes from this station were collected during a four-week period from the middle of July to the middle of August. In areas such as this, chemical treatment is generally necessary as an adjunct to water management if the larval populations are high enough to warrant this control.

On the Wheeler Test Area, mosquito production was higher in 1964 than in 1963 on Sampling Stations 2B, 4, 9, 11, 13, and 14 (Appendix Table 7). The Wheeler Area was not sampled for mosquito production in 1962.

Sampling Station 2B was plowed in preparation for leveling in the fall of 1963. This plowing resulted in the formation of numerous small pot holes which provided a mosquito-producing habitat in the spring and early summer of 1964. These mosquitoes were mostly A. dorsalis. Further leveling of this station, which was accomplished during the summer and fall of 1964, should eliminate the mosquito production as was done in Stations 1 and 2A. Sampling Station 4 consists of the grassy upper edges of a reservoir. When the water level was high enough to extend into this grass, larvae were found. On the lower edges of this same reservoir where there is no vegetation, there is no mosquito production.

Sampling Station 9 was flooded for a longer period of time in 1964 than in 1963 and consequently the mosquito production was higher. The mosquitoes produced as a result of this longer period of flooding were primarily Culex tarsalis.

Sampling Station 11, a small, very shallow pond, retained water during the entire season and the production of C. tarsalis continued during most of the season. The water for this station resulted from seepage from a water channel.

No mosquito larvae were found in 1963 in Sampling Stations 13 and 14. In 1964 larvae of A. dorsalis were collected once in Station 14. This station consists of an old salt drying bed that is being converted into a water storage reservoir. Some vegetation is now beginning to grow along the edge of this pond and it was in this vegetation that the larvae were found. Station 13 is also an old salt drying bed. The larvae of C. tarsalis were found in the vegetated edges of this sampling station in 1964.

3. Vegetation:

In Annual Report Number 1 (Rees, et al. 1963), vegetation found in the marsh areas was listed under the headings submerged aquatics, free-floating aquatics, emergent marsh plants, moist soil plants, upland weeds and herbs, and brush and trees. Because the land is flat and the water fluctuates in amount, the areas occupied by these vegetation types are not generally separated into distinct zones but are quite broadly overlapping. This is especially true of the emergent marsh plants and the moist soil plants.

In the study areas, no mosquito problem is involved in the brush and tree or the upland weed and herb areas. These vegetation types are found on the higher ground and are not subject to inundation.

The areas occupied by the moist soil plants are generally the most prolific in mosquito production. The most widespread moist soil vegetation in the study areas is salt grass (Distichlis stricta). These salt grass areas are generally located on the upper end of the impoundments and are subject to flooding and draining with changes in the water level. This situation is conducive to the production of large numbers of A. dorsalis mosquitoes and if the water remains for a sufficient length of time, species of Culex and Culiseta mosquitoes are also produced. The luxuriant growth of the salt grass serves to stagnate the water and provide suitable shelter for the laying of the eggs, the development of the larvae and the pupae, and the adult mosquito emergence. The mosquito production in the salt grass areas varied with the density of the vegetation, the depth of the water, and with water fluctuation. The mosquito production was higher in the denser vegetation and also greater in water depths of four to eight inches than in lesser or greater depths. Sampling Stations 1 and 10 on the Lake Front Gun Club are both covered predominantly by salt grass and yet the mosquito production has been much higher in Station 1 than in Station 10. The water level in Station 10 has been kept fairly stable and relatively deep (around 8 to 12 inches) while the water level in Station 1 has been less stable and generally shallower (4 to 8 inches). A similar comparison can be made between Sampling Stations 8 and 10 on Farmington Bay. Both are covered by salt grass mixed with some emergent vegetation. The mosquito production on Station 8 has been higher than on Station 10 during the three years of this study. The water levels have fluctuated on Station 8 and the water depth has been from about 6 to 10 inches. The water level on Station 10 has been more stable and the water depth shallower (2 to 6 inches). Most of the larvae collected on Station 10 were collected in the east part of the station in the deeper water (4 to 6 inches).

The predominant emergent marsh plants in the study areas are cattail (Typha sp.), alkali bulrush (Scirpus paludosus), and Olney's bulrush (Scirpus olneyi). There are lesser stands of hardstem bulrush (Scirpus acutus) and other plants. The mosquito production in the emergent marsh vegetation is generally less than in the salt grass areas; however, the production varies with the vegetation type, vegetation density, and water depth and extent of fluctuation.

Cattail and Olney's bulrush are found growing in Sampling Station 14 on Farmington Bay and separate collections were made from these two vegetative types. These stands of vegetation were adjacent and the water depths were the same. Olney's bulrush had an average larval population of 1.61 larvae per dip, the cattail 0.21. The height of the vegetation appeared not to be significant as collections made in this same area from Olney's bulrush which had been clipped by muskrats averaged 1.60 larvae per dip. The latter, however, was in vegetation which was not clipped below the water surface. Sampling Station 2 on Farmington Bay consists of nearly a pure stand of alkali bulrush. Mosquito production in this station has been very low for all three years of the study. On Sampling Station 7 on Farmington Bay, the vegetation is a mixture of alkali bulrush and salt grass. The mosquito larvae collected from this station have been collected only from the salt grass areas. Aedes dorsalis mosquitoes were found in reflooded emergent marsh areas. As in the salt grass areas, the mosquito larvae were less abundant in the areas where the water was deeper.

Duckweed (Lemna minor L.), a free-floating aquatic plant, is found abundantly in the marsh areas. During August of 1964 this plant formed a dense mat covering the entire water surface on Sampling Station 14, Farmington Bay. No mosquito larvae were found on this station while this mat was intact. In other areas, larvae were collected from the duckweed vegetation where there were breaks in the mat.

The most abundant submergent marsh plants found in the study areas are muskgrass (*Chara* spp.), sago pondweed (*Potamogeton pectinatus* L.), and widgeon grass (*Ruppia maritima* L.). No mosquito production was found associated with these plant types.

4. Climatic Conditions:

Climatic factors, especially precipitation and temperature, significantly affect mosquito production in the study areas. The precipitation in the study and in other areas, particularly the watersheds, plays a large role in determining the amount of water available. Not only the amount of water but also the time when it is available are both important factors in mosquito control. These factors were discussed previously.

Temperature plays an important role in the rate of development of the immature stages of the mosquitoes and in the activity of the adults. Because of low temperature, there is no mosquito problem during the late fall, winter, and early spring months. Generally, the flooding of marsh areas just prior to the opening of the waterfowl hunting season in the middle of October does not create a mosquito problem other than in the marshes. The low temperatures during this time of the year retard the larval development and restrict the activities of the adults.

Such factors as humidity and wind velocity and direction probably play a role in the biting activities and the dispersal of the adult mosquitoes.

A summary of weather and climatic data is presented in Appendix Table 40 and Appendix Figures 11 and 12.

5. Other Factors:

Other factors such as salinity and water quality also probably affect mosquito production in the marsh areas. *Aedes nigromaculis* and *Anopheles freeborni* have been collected as adults but not as larvae in the study areas. These mosquitoes are produced in adjacent areas but are not established in the marshes although the marsh areas are within the flight range of the adults of these species. Other mosquitoes of this area are included in this category. The factors preventing the establishment of these species in the study areas has not been a part of the present study but it presents an interesting problem for consideration.

III. WILDLIFE PRODUCTION

A. Birds

1. Kinds:

A checklist of the birds found in the study area, the seasons when present, and relative abundance is contained in Annual Report No. 1 (Rees, et al. 1963). A list of birds observed at Ogden Bay Refuge 1940 to 1954 by Noland Nelson served as a basis for preparing this list which was modified as a result of observations made by the investigators and by the aid of personnel of the Ornithology Museum, University of Utah.

2. Numbers:

The manager of the Farmington Bay Waterfowl Management Area made waterfowl counts on the 15th and last day of each month. These counts were made from the dikes by means of a "spotting scope." The counts included ducks, geese, coots, and swans. The results of these counts are presented in Appendix Table 15.

Nesting surveys were conducted at each larval sampling station and in adjacent areas. These surveys were made by two to four persons walking abreast over a given transect. A rope was dragged over the vegetation between the persons to aid in flushing the birds. As the birds were flushed, the nests were located and desired data recorded. Identification of the eggs was made from the identification of the flushed bird whenever possible. The number and kinds of eggs, type of vegetation, and water depth were recorded. Also the flooded and deserted nests were noted. The data from this study are presented in Appendix Table 17.

There were fewer waterfowl nests found in the sampling stations in 1964 than in 1963. The greater water depth in the sampling stations probably accounts for the reduction of nests in these areas. However, more nests were found in the areas adjacent to the sampling stations in 1964 than in 1963. These nests were located on the dikes and in the upland vegetation adjacent to the water. Fewer flooded nests but more deserted (nonflooded) nests were found in 1964 than in 1963. Since many of the nests were located above the impounded areas, there was no danger of their being flooded. Probably the heavy rains which occurred in the spring and early summer of 1964 accounted for a large number of nests being deserted. The deserted nests were found in all parts of the marsh.

Bag checks are made on the number and kinds of waterfowl killed on Farmington Bay Waterfowl Management Area during the first weekend of the hunting season. A tabulated summary of these waterfowl bag checks for 1962, 1963 and 1964 is presented in Appendix Table 18. Hunter success was lower in 1964 than in 1962 or 1963. The hunter success during the rest of the season was described as spotty by Reuben Dietz, manager at Farmington Bay. He attributed the generally poor 1964 hunting season to two factors: 1) weather, and 2) the abundance of feed on the edge of the Great Salt Lake. The opening day of the hunting season was calm and clear and the ducks flew high and away from the hunting areas. The large amount of water released on the mud flats bordering the lake during May and June of 1964 resulted in the production of a large amount of feed in this area. The ducks remained on this feeding ground instead of moving into the impounded areas of the Farmington Bay Waterfowl Management Area and the Lake Front Club. Goose hunting on Farmington Bay was better in 1964 than in 1963 but poorer than in 1962. No swan kills were reported at Farmington Bay during the 1964 hunting season.

On the Lake Front Gun, Fur and Reclamation Club, it was estimated that 420 ducks and 5 geese were taken by 70 hunters on the opening weekend of the 1964 waterfowl hunting season, compared with 560 ducks and 7 geese in 1963 during a similar opening period. These results are comparable to those obtained at Farmington Bay.

3. Factors Influencing Waterfowl Production:

a. Water: Water quantity and water quality are both important factors influencing wetland wildlife production. Both of these factors are quite variable throughout the year. Without proper management, a fluctuating water supply can result in fluctuating impoundment areas with an accompanying flooding and destruction of waterfowl nests. Stable water levels are also desirable for maintaining good conditions for optimum plant growth.

Water quality, especially with regard to salinity, is an important factor in the determination of the type of plants which will grow in an area. Much of the water entering into the study areas is return flow irrigation water and the salt content is too high for agricultural purposes. Most of this water is not above the salt level that would have a detrimental effect on the prevalent marsh plants and can therefore be used advantageously in the marsh areas. The salt content of the water on the Wheeler Test Area was much lower than that in Farmington Bay or the Lake Front Club and the water from this area can be used for agricultural purposes. A more detailed discussion of water quality will be presented in a later section of this report. Papers by J. B. Low and Don Smith, found in the appendix of this report, also discuss water quantity and quality in waterfowl management.

Summaries of the data collected on water quality and quantity are presented in Appendix Tables 19-29 and Appendix Figure 4.

b. Vegetation: The vegetation type, density, interspersion, and vegetation water interrelation are all important factors in the consideration of the effect of vegetation upon waterfowl production. The utilization of the vegetation by waterfowl for food, nesting, and cover is also important.

The submergent aquatic vegetation, sago pondweed, widgeon grass, and chara, is used extensively by the waterfowl for food. Duckweed is the most important food plant of the free floating aquatics. Alkali bulrush, followed by hardstem bulrush and Olney's bulrush, is the most important food plant of the emergent marsh plant group. The moist soil plants are of lesser value for food although the smartweeds (Polygonum spp.)

and millets (Echinochloa spp.) are excellent food plants where they are found. Glasswort, if flooded, may also be used for food by the waterfowl. The upland vegetation of weeds, herbs, and brush is generally unimportant as food for waterfowl although it may play a role in the production of food, shelter, and nesting sites for upland birds.

Neither the submerged nor the free floating aquatic vegetations play an important role in the nesting of the waterfowl but the emergent marsh plants are very important. In situations where the nests are constructed on or over the water, Olney's bulrush appears to be the most important plant. In 1963 and 1964 the greatest nesting density on impounded areas was found in stands of Olney's bulrush. Hardstem bulrush is also an excellent nesting plant but this plant is not nearly as widespread as Olney's bulrush. Cattails are used to some extent for nesting but the nests of this plant are of lower quality and tend to become saturated with water. Alkali bulrush serves as a nesting material but it is generally used in non-impounded areas where the nests are built on the ground or in areas flooded to only 1 or 2 inches. Yellow-headed blackbirds and marsh wrens used all of the emergent vegetation for nesting. Salt grass areas which were not flooded were used extensively for nesting. Few nests were found in flooded salt grass and many of the nests which were found were destroyed by flooding. Glasswort (Salicornia rubra A. Nels.), another moist soil plant, was utilized by the black-necked stilts and the avocets for nest construction. These nests were abundant on the unflooded mud flats of Sampling Station 7 on Farmington Bay. Pickleweed (Allenrolfea occidentalis (Wats.) Kuntze), a moist soil plant which occupies a slightly higher elevation than the salt grass or glasswort, was used by the ducks for nesting. More nests were found in the pickleweed areas in 1964 than in 1962 or 1963. The greater abundance of water with accompanying higher water levels in 1964 forced the ducks into this upper area. Relatively few duck nests were found in the upland weed and herb area.

Both emergent marsh vegetation and moist soil plants are used extensively for cover by the waterfowl.

c. Weather: Weather and climatic factors influence both the water conditions and the vegetation which in turn influence the waterfowl production. The weather conditions can also have a direct influence on the waterfowl. As was discussed previously, the heavy precipitation during the 1964 nesting season was probably responsible for the high number of deserted nests. The weather conditions during 1964 will be discussed in greater detail in a later section. A summary of the weather data is presented in Appendix Table 40 and Appendix Figures 11 and 12.

d. Disease: Botulism plays an important role in waterfowl production in the marsh areas. In 1963 many man-hours were spent by the Fish and Wildlife Service in collecting and treating botulism afflicted ducks (Rees et al. 1964). In 1964 the amount of botulism was not considered sufficient to make such treatment necessary. A greater abundance of water and lower summer temperatures are considered as factors probably responsible for reducing the botulism problem in 1964.

B. Other Wildlife

1. Muskrats:

Muskrats have been trapped commercially on both the Lake Front Gun, Fur and Reclamation Club and the Farmington Bay Waterfowl Management Area for many years. Muskrat trapping has not yet been attempted on the Wheeler Test Area although these animals are present. The number of rats trapped on Farmington Bay from 1960 to 1964 is presented in Appendix Table 16.

On Farmington Bay in 1963, 60% of the marsh area was closed to trapping. It was hoped that a larger number of rats would aid in opening up the dense stands of cattail that are found in the area. Sixty-five per cent of the rats caught in 1963 were caught within 100 feet of the dikes and damage to the dikes by the burrowing rats was observed. In 1964 the entire Farmington Bay Area was opened to trapping and a larger number of rats was trapped than in 1963.

2. Fish:

In addition to the fish listed in the Annual Reports for 1962 (Rees et al., 1963) and 1963 (Rees et al., 1964), black bullhead catfish (*Ictalurus melas* (Rafinesque)) were observed in great numbers during 1964 in the main pond of the wildlife area of the Wheeler Test Area. These fish are common in the drainage systems of rivers of this area.

Five tons of carp (*Cyprinus carpio* (Linnaeus)) were removed from Farmington Bay by commercial fisherman in 1964. These fish are considered detrimental to the wildlife area in that they destroy food which could be utilized by the waterfowl. The activities of commercial fishermen have aided in controlling the carp populations on Farmington Bay. These fish are used for fertilizer, fish food, and for human consumption.

3. Reptiles and Amphibians:

In 1964 a study of the reptiles and amphibians on the study areas was initiated. This study consisted of observing, collecting, and identifying the animals present. No quantitative study was attempted other than an estimate of the relative abundance of the species present. James Christensen, graduate student in herpetology, University of Utah, aided in this study.

The following reptiles and amphibians were collected or observed on the Lake Front Gun Club:

Snakes: Wandering Garter Snake, *Thamnophis elegans vagrans* (Baird and Girard)
Red-sided Garter Snake, *Thamnophis sirtalis parietalis* (Say)
Lizards: Great Basin Sagebrush Lizard, *Sceloporus graciosus graciosus* Baird and Girard
Northern Desert Horned Lizard, *Phrynosoma platyrhinos platyrhinos* Girard
Amphibians: Leopard Frog, *Rana pipiens* Schreber

This study was incomplete and other species will be found as the study continues.

IV. INTERRELATIONSHIPS OF MOSQUITO CONTROL AND WILDLIFE MANAGEMENT

Mosquitoes and waterfowl have a common denominator in that both require water for their existence. In the minds of many people, marshes are synonymous with mosquitoes while to other people marshes mean wildlife, particularly waterfowl. It is true that many kinds of mosquitoes are found, sometimes in great numbers, in marsh areas and it is also true that marsh areas support large numbers and a wide variety of wildlife. However, not all parts of the marsh are mosquito producing and areas in which mosquitoes are found are not all equal in mosquito production. It is evident also that all marsh areas and situations are not equally desirable as wildlife habitats.

Mosquito production and distribution on the marsh are affected by water fluctuation, water depth, water quality, vegetation type, vegetation density, climatic conditions, and mosquito abatement activities The influence of the above factors was discussed in a previous section of this report. The above factors also affect the production, distribution, and management of wildlife of the marsh areas. The influence of these factors on the wildlife was also discussed in a previous section.

A suitable marsh for waterfowl should provide for good nesting, feeding, cover, and loafing areas. From the standpoint of mosquito control, a good marsh is one which does not produce excessive numbers of mosquitoes. A desirable water management program on the marsh areas should then be one which provides for the basic requirements for the waterfowl and other wildlife and yet is compatible with mosquito control principles. Where and if conflicts exist between these interests, cooperative management programs should be devised and operated for the greatest benefit of each.

To date this study indicates that water management in the marsh areas can be mutually beneficial to mosquito suppression and wildlife management if this management program is planned to meet requirements for the multi-purpose objectives of land and water use and these management programs are cooperatively formulated and conducted by all persons involved in the use and management of this land and water.

Although a water management program should be adapted to an individual area according to the proposed use of the area, the availability of the water, and the quality of the water and soil, certain generalizations which are applicable to all areas can be made.

(1) Stabilization of water levels on impounded areas is desirable for both mosquito suppression and wildlife management. This stabilization of the water prevents widespread flooding of adjacent areas which often results in the extensive production of Aedes dorsalis, the floodwater mosquito. The permanent water mosquitoes, Culex and Culiseta, are also produced in this flooding situation if the water remains standing for a sufficient length of time. Permanent water mosquitoes which develop in the emergent vegetation of the impounded areas can be reduced by regulation of the water depth within the impounded area. Holding the water high, above 12 inches, during the spring and early summer months, a gradual draw-down during the summer months, and reflooding late in the season just prior to the opening of the hunting season have been successful in reducing the numbers of the permanent water mosquitoes.

Stabilization of the water levels prevents the flooding of waterfowl nests which often occurs with a rapid increase in the amount of water on a marsh without confinement in a definite area. Stabilization also promotes the growth of desirable emergent and submergent aquatic plants which are used extensively by the waterfowl for food, nesting, and cover. Stable water levels also serve in the conservation of water in that increased water supplies result only in deepening of the impounded water rather than an increase in the impoundment area. Therefore, less water surface area is available to the forces of evaporation.

Stabilization of water levels can be aided through the construction of adequate physical facilities such as dikes, abrupt edges, adequate and adjustable inlets and outlets, adequate channels, and by-pass canals and drains where needed.

(2) Well defined units in which water can be controlled in amount, rate of flow, depth, duration, removal, and other water management requirements are desirable for mosquito control and wildlife management. These units should be small enough that the water can be adequately managed separately on each unit. The number of units operated each year may vary according to the availability of water. Also the number of units kept flooded during the entire year would vary with the available water. Some units would be flooded only in the spring and again in the fall, being kept dry during the summer months. Only those units for which there was available water would be operated and only during the season when water was available. This would allow for an adequate water management program during years and seasons when the water supply is low as well as seasons and years when water is plentiful. The units flooded and dry could be rotated from year to year to produce desirable changes in the vegetation in the units. This rotation of flooded and dry units could also be used as a control method for nuisance vegetation such as cattails. Areas which have become densely covered by cattail could be dried and the cattails could then be removed by burning or mechanical means such as cutting or cultivation.

(3) Irrigation of non-impounded areas may be desirable in some cases to initiate the growth of desirable marsh plants. This type of water management is being practiced on Sampling Station 7 on the Farmington Bay Waterfowl Management Area. This area is flood irrigated in the spring and early summer and then reflooded in the fall if water is available. This type of irrigation is producing an alkali bulrush marsh with a few patches of salt grass. The water in this area is generally shallow and moving. The mosquito larvae that are collected are found in small isolated pot holes in the salt grass vegetation. To date this type of situation has not been a serious problem in mosquito production. With a greater invasion of salt grass in this area, the mosquito problem could significantly increase. Further study on the factors involved in producing an emergent marsh rather than a salt grass marsh should be made. This area is used extensively by ducks and other waterfowl for nesting and feeding. Both the salt grass and alkali bulrush vegetation is used for nesting material. These nests are generally located on the higher non-flooded ground. The alkali bulrush provides an abundant food supply for the waterfowl.

(4) Water management programs for each specific area must be the result of cooperative efforts of all persons involved. This cooperation must exist in the policy making echelons and among the field workers. This cooperative effort should also be exerted in the realms of research as well as in practical applications.

(5) Water management practices which are beneficial to both mosquito abatement and wildlife management can be and have been put into operation on the three study areas.

Appendix Figure 3 makes a comparison of the habitat requirements of mosquitoes and waterfowl in a marsh area.

V. WATER

A. Quality

1. Biochemical Oxygen Demand (BOD):

The BOD sampling program initiated in 1963 was continued in 1964. Four one-gallon samples of water from selected stations were submitted monthly during the period April through September to the Utah State Health Department Laboratory for the determination of the 5-day biochemical oxygen demand and pH. Test methods used were those specified in "Standard Methods for the Examination of Water and Waste Water" (USPHS 1962).

The four water sampling stations included the northwest reservoir of the Wheeler Machinery Company Test Area, a site near the first foot bridge on the Turpin Dike on the Farmington Bay Waterfowl Management Area, the State Canal south of Farmington Bay, and a marsh pond on the Lake Front Gun Club.

Data pertaining to the biochemical oxygen demand of the sewage effluents of the four sewage treatment plants in Davis County were obtained from records maintained at the sewage treatment plants. All determinations were made at a commercial laboratory. Figures in Appendix Table 20 show the averages for the days the samples were taken rather than for the entire month.

Based on a 5-day BOD all six of the water samples taken from the Wheeler property came within the limits of Class "C" water as established by the Utah Water Pollution Control Board's "Classification of Waters of the State." Samples from the Turpin Dike station on Farmington Bay were within the Class "C" limits except for the samples taken during April and September. Of the five samples taken from the State Canal only the sample taken in June had a BOD determination within Class "C" limits. This sampling station is located about one half mile below the effluent outfall of a sewage treatment plant. On the marsh pond of the Lake Front Gun Club all samples were within Class "C" limits except for the sample taken during September. Data pertaining to BOD and pH determinations at the four sampling stations are contained in Appendix Table 19.

Approximately seventy per cent of the monthly average BOD's of the effluents of the four sewage treatment plants in Davis County exceeded the limits established for Class "D" water. See Appendix Table 20 for additional details. Definitions of Class "C" and Class "D" waters are presented in Appendix Table 30.

2. Bacteriological Determinations (MPN):

Four samples of water were taken from selected stations each month during the period April through September for bacterial analysis to determine the most probable number of coliform organisms in 100 milliliters of water (MPN). The samples were taken from the same stations from which BOD determinations were made. Bacteriological analyses were accomplished in the laboratory of the Utah State Department of Health.

A limited number of MPN determinations were made of the sewage effluents at each of the four treatment plants in Davis County. The samples were taken at infrequent and irregular intervals by personnel of the Utah State Department of Health.

Based on MPN's alone, the waters at three of the four sampling stations were within the Class "C" limits. At the State Canal station only the samples taken during May and September were within Class "C" limits. See Appendix Table 19 for details. All MPN determinations at the four sewage treatment plants exceeded Class "D" limits. See Appendix Table 20 for details.

It should be noted that the effluents of three of the plants will be chlorinated commencing about January 1, 1965. This should result in considerable improvement in the quality of the effluent.

3. Salinity:

The total concentration of soluble salts is a characteristic of water which greatly influences its suitability for plant propagation. This characteristic can be adequately expressed for purposes of diagnosis and classification in terms of electrical conductivity. The conductivity is useful because it can be readily and precisely determined.

Nine water samples were obtained weekly during the period April through mid-October and tested in the laboratory for electrical conductivity, expressed in micromhos per centimeter. Four of the samples were taken from water sources on or adjacent to the Wheeler Machinery Company Test Area, namely the northwest reservoir, Farmington Creek, the stream entering the Wheeler property from the north and the stream entering from the east. Five samples were taken weekly on the Lake Front Gun Club at water sampling stations designated: west of front gate, big lake, Y-dike, area 10 weir, and chain gate.

The electrical conductivity was determined by direct readings from a Solu-Bridge soil tester following the procedure recommended by the Soil Conservation Service with Agriculture Handbook No. 60 used as a reference. Data are contained in Appendix Table 21.

A water sample was collected from each of the nine sampling stations during the months of May, August and September. The samples were submitted to the Soils Laboratory, Agricultural Experiment Station, Utah State University, for detailed analysis of chemical constituents which affect the quality of water for agricultural use. The chemical analysis included the sodium absorption ratio, total dissolved solids, electrical conductivity, water classification based upon salinity and sodium hazard and determination of the following ions: Cations-calcium, magnesium, sodium, potassium, Anions-chloride, sulfate, carbonate, and bicarbonate. Details of the analyses are contained in Appendix Tables 22 and 23.

All water samples taken on the Lake Front Gun Club were generally rather highly saline. They were conductivity Class 3 or 4, and almost all were S-2 in sodium hazard. If the waters are to be used for irrgation, the crops on which they are used would generally require a high salt tolerance. The better waters could be used on grain crops and alfalfa. Barley and the more tolerant grasses might produce fair yields provided soil salinity conditions are no higher than that of the waters.

Water from all four sampling stations on the Wheeler Machinery Company Test Area are of good quality and could be used for irrigation, fish and wildlife use, and for livestock watering based on chemical evaluations. Classification of waters based on salinity and sodium hazard is presented in Appendix Table 31.

4. Miscellaneous:

Personnel of the Geological Survey have been gathering water quality and quantity data along the Jordan River and the Surplus Canal during the past year (see map on page 4). Because much of this water enters two of the areas under investigation, the data gathered by the Geological Survey will allow comparison of water quality before it enters and after it has passed through the wetlands area. Included are chemical quality analyses for the Jordan River at 2100 South, Salt Lake City; chemical quality and specific conductance data on the Jordan River below Cudahy Lane, north of Salt Lake City; chemical quality and specific conductance data for the Surplus Canal at Cohen Flume, northwest of Salt Lake City; and one determination on the outflow from Farmington Bay.

As indicated by specific conductance on the Surplus Canal at Cohen Flume and the Jordan River at 2100 South, chemical quality of the water at the two points is about the same.

Data received from the Geological Survey are included as Appendix Tables 24-29.

B. Quantity

As discussed in the two previous annual reports of this study (Rees et al. 1963, Rees et al. 1964), the principal water supply for the Lake Front Gun Club and the Farmington Bay study areas is the Surplus Canal and the Jordan River. In addition, the Farmington Bay study area receives water from several streams along the Wasatch Front in Davis County. Water available from these streams is negligible during the summer because it is diverted for irrigation purposes.

The U. S. Geological Survey, Surface Water Branch, as part of a study on the water resources of Salt Lake County, and in cooperation with this program, has established continuous recording water gauging stations at: Jordan River at 2100 South, Salt Lake City and at Cudahy Lane, north of Salt Lake City; Surplus Canal at 2100 South and at Cohen Flume, northwest of Salt Lake City; North Point Canal at North Temple Street, Salt Lake City; and the Goggin Drain, northwest of Salt Lake City. Appendix Tables 32-38 show the daily discharge in cubic feet per second at these gauging stations. The location of these streams and gauging stations is shown on the map on page 4.

A report of the water resource study of Salt Lake County is provided in the appendix of this report on page 124.

Water was abundant during May and June of 1964 as a result of above normal precipitation and heavy run-off from snow in the mountains (Appendix Tables 32-38). A comparison for 1962, 1963, and 1964 of the daily mean discharge in cubic second feet per month is shown in Appendix Figures 5-10. It is apparent there was considerable increase in the amount of water in 1964 compared with the previous two years.

Appendix Figure 7 shows a comparison by month of the daily mean discharge of the Jordan River at 2100 South for a three year period, 1962, 1963 and 1964. An additional gauging station was operated on the Jordan River at Cudahy Lane during 1964. Appendix Figure 8 provides a comparison of the flow in the Jordan River at 2100 South and at Cudahy Lane. During periods of high precipitation, gates on the river are closed at 2100 South and the water is diverted into the Surplus Canal in order for the storm drain system of Salt Lake City to empty into the river. As shown in Appendix Figure 8, the record of the amount of water in the Jordan River as determined by the average at 2100 South is misleading as the actual flow in the Jordan River is greatly increased below 2100 South by the discharge into the river of the storm drains from the city.

During periods of high water, it is possible to divert water from the lower end of the Surplus Canal through the Goggin Drain directly west to the Great Salt Lake. The daily mean discharge of water diverted into the Goggin Drain is indicated in Appendix Table 37 and Appendix Figure 5. Appendix Table 38 and Appendix Figure 6 show the amount of water diverted from the Surplus Canal at Second South by the North Point Canal for Salt Lake City irrigation purposes.

Inasmuch as there was an abundance of water early in the season, it was possible to fill the diked marsh areas with the available water and retain these high water levels for a long period of time and thus reduce in 1964 the production of Aedes dorsalis in many of the marsh areas.

Effluents from sewage treatment plants represent another water source to the study areas. The two sewage treatment plants of the South Davis County Sewer Improvement District discharge their effluents into waters flowing into the Farmington Bay Refuge. This effluent discharge averages 3.88 million gallons per day. The effluents from the Central Davis and North Davis sewage treatment plants do not enter into the present study area but they are discharged on the shores of the Great Salt Lake and are used in creating pasture and marsh areas. These discharges also constitute a problem in mosquito production.

The sewage effluent from Salt Lake City is untreated and flows by means of a sewage canal into the Great Salt Lake. This effluent in its present condition serves no beneficial purpose. A sewage treatment plant for Salt Lake City is in the process of construction and upon completion will provide an additional source of reusable water. This additional source will average about 32 million gallons per day.

The daily average flow of treated and untreated sewage effluents from Salt Lake City and Davis County is presented in Appendix Table 39.

VI. WEATHER

A. Temperature

A monthly summary of temperature deviation from the established norm is presented in Appendix Figure 12. These data were obtained by the U. S. Weather Bureau at the Salt Lake City Municipal Airport Weather Station.

As stated previously in the report, temperature plays an important role in determining the time required for the development of the larval stage of the mosquito and in the activity of the adults.

During April, May, and June the mean average temperatures were 4.3, 3.1, and 4.2 degrees below normal. The low temperatures during this time of the year retarded the development of the larval stage of the mosquitoes. Following this three month period, July was 0.6 of a degree above normal, with August and September again below normal.

Late flooding of the areas of the marshes that were dry during the summer combined with below normal temperatures in September aided in reducing the mosquito nuisance that might have occurred at this time of the year.

B. Precipitation

A summary of precipitation deviation from the established norm for 1964 and a comparison with 1963 are presented in Appendix Figure 11. These data were also obtained from the Municipal Airport Weather Station of the U. S. Weather Bureau.

A comparison of precipitation in 1964 with 1963 shows a striking difference in the amount of precipitation and when it occurred. During the four-month period of March, April, May, and June of 1964 precipitation totaled 10.33 inches. This compares with the norm of 5.7 inches for this period. In addition to the precipitation there was a high run-off from the snow pack in the mountains. In the following four-month period of July, August, September, and October, precipitation was below normal each month with a total of 1.01 inches of precipitation. The established norm for this four-month period is 3.13 inches.

In September, 1963, a Class "A" evaporation station was installed at the Farmington Bay Waterfowl Management Area under the direction of Mr. Eugene Peck, hydrologist in charge, U. S. Weather Bureau, in cooperation with the Utah State Department of Fish and Game and the Salt Lake City Mosquito Abatement District. This station was operated during 1964 and daily readings were made by Mr. Reuben Dietz, manager of the refuge, and the data are included in Appendix Table 40 of this report.

A discussion of the evaporation station by Mr. Peck is presented in the appendix of this report. The evaporation measurement data will be evaluated by Mr. Peck and will give much needed information concerning evaporation on the marshes during the various times of the year.

VII. ENCEPHALITIS SURVEILLANCE

Two sentinel chicken flocks were established in the study area during 1963 by the Disease Ecology Section, U. S. Public Health Service, Greeley, Colorado. The purpose of sentinel chicken flocks is to provide indices on seasonal transmission of the arthropod-borne encephalitides in a circumscribed area.

Two new flocks of thirty chickens each, two portable sheds and pens for housing them were provided in 1 64 and set up under the direction of personnel of the Disease Ecology Section. One sentinel flock was established at the Farmington Bay Waterfowl Management Area. The site selected for the second flock was near the Jordan River at 2500 North in the northwest section of Salt Lake City. At each sentinel flock location light traps were operated and regular biting collections were made during the season to provide data concerning population levels of those mosquitoes capable of transmitting encephalitis viruses.

On September 30, 1964, blood samples were taken from the chickens and tested by the Disease Ecology Section to determine the presence and incidence of Western Equine Encephalitis (WEE) and St. Louis Encephalitis (SLE) virus in each sentinel flock. This provides an index on seasonal transmission of these viruses in the area of the sentinel flock. The results of the tests are given in the following table:

HAI Antibody Rates in Utah Sentinel Chicken Flocks
September, 1964 Bleeding
Prepared by Public Health Service, Disease Ecology Section
Greeley, Colorado

Area	WEE McMillan	SLE Parton
Salt Lake County:		
Alva H. Tippetts 2500 N. Redwood Road	* 30-0-0	* 30-0-0
Davis County:		
Farmington Bay Waterfowl Management Area Headquarters	* 28-0-0	* 28-0-0

* Numbers represent number tested, number positive, and percent positive.

VIII. THE BITING DEERFLIES AND HORSEFLIES IN THE MARSHES OF THE GREAT SALT LAKE
(Diptera - Tabanidae)

In the fresh water marshes bordering the Great Salt Lake, mosquitoes, deerflies and horseflies create a serious annoyance to man and other animals on which they feed during certain seasons of the year. In addition they are capable of transmitting the causative organisms of certain diseases to the host from which they take their blood meals.

An extensive study has been made of the mosquitoes in these marshes and an effective mosquito control program is in operation but little has been done to study or control the deerflies and horseflies. As a result the mosquito populations have been greatly reduced in numbers but the deerflies and horseflies, if they have not increased in numbers, have become more conspicuous by comparison and therefore more annoying.

During the 1964 season an undergraduate student, majoring in biology at the University of Utah, was able, with the support of a National Science Undergraduate Fellowship, to make a study of the deerflies and horseflies on the Lake Front Gun, Fur and Reclamation Club. This club is one of the study areas used in the cooperative water management study now in progress. In this study an attempt was made to determine the relative abundance and importance of the deerflies and horseflies present on the marshes as an annoyance and possible disseminator of disease organisms to man. In making this study, life history, habits and the basic ecology of each important species were investigated. It is proposed to continue the study in 1965 and extend the scope to include the effects of these tabanids on animals other than man. Possible methods of control, including the effects of water management, will also be included.

As a result of this study, in 1964 on the Lake Front Club which is assumed to be typical for marshes in this area, the following common species of Tabanidae were collected:

Deerflies - *Chrysops discalis* Williston
Chrysops aestuans Van der Wulp

Horseflies - *Tabanus punctifer* Osten Sacken

These three species were extremely abundant and annoying during the latter part of July and during August and September. They feed voraciously on man and other animals during the day time and at times were present in such great numbers that it was impossible to escape their persistent attacks.

IX. PROGRESS ON THE WHEELER MACHINERY COMPANY TEST AREA

Equipment testing and land leveling have continued on the Wheeler property. Acreage previously planted in barley was re-leveled in preparation for pasture planting. Other plots, recently leveled, were fall planted, primarily with barley.

Two additional reservoirs have been constructed and the irrigation system has undergone extensive development so that water can be managed more efficiently.

Land has been leveled adjacent to the old salt drying beds in preparation for the spring construction of irrigated fields and dikes in the waterfowl area. Construction is to proceed in accordance with the Soil Conservation Service plan for optimum use of the land for crop production beneficial to waterfowl.

The water resting and mosquito sampling program initiated in 1963 was continued in 1964. The results of these programs are discussed in previous sections of this report.

X. CROPS

During 1964 each of the three research areas was more extensively planted with selected crops than in previous years. A small trial planting area was developed on the Lake Front Gun Club in cooperation with the Soil Conservation Service. A detailed report of this trial planting is presented on page 130.

A similar trial planting was undertaken at the adjacent North Point Gun Club. Since the quality of the soil and water is comparable, the results of that investigation are included on page 131.

In addition to the above plantings, white sweet clover and tall wheatgrass were planted on the newly constructed dikes of the Lake Front Gun Club. This planting was done in October, 1964 and no results are yet available.

In the Farmington Bay Waterfowl Management Area, corn, milo, and an experimental plot of German and Japanese millet, sweet Sudan grass, buckwheat and white proso were planted in a cultivated area. These plantings were sprinkle-irrigated throughout the summer resulting in successful growth. The plants were extensively used by wildfowl after they had matured.

In a separate trial planting the previously mentioned plants, exdept corn, were planted in a lake bed and flood irrigated throughout the summer. About three-fourths of an acre of Japanese millet germinated and matured. The other plantings did not germinate. The successful planting was in a sandy-clay type soil. The other plants, including a strip of Japanese millet, were planted in a heavy clay type soil.

According to the manager of the waterfowl area, waterfowl utilization of the Japanese millet was astonishing. Two days after flooding about 200 ducks and 6 Canada geese were feeding in the area. By the seventh day approximately 800-900 ducks and 42 Canada geese were on the area. On the ninth day very few birds were present. An inspection of the planting showed complete utilization of the seed heads.

A tall wheatgrass-sweet clover mixture was broadcast on the Unit 3 dike face during early spring. Germination and plant growth were excellent on this dike.

XI. CONSTRUCTION

A. Proposed Farmington Bay By-pass Channel

Several meetings have been held to discuss the proposed Farmington Bay by-pass channel. The Utah State Department of Fish and Game and the Bureau of Reclamation have stated their willingness to proceed as rapidly as circumstances will allow. The by-pass channel is part of an extensive drainage system planned for the southwest area of Davis County, and its construction is contingent upon concurrent construction of lateral field drains which will empty into the by-pass channel. Failure to obtain rights-of-way for lateral drains has delayed the project. Renewed emphasis is being placed upon the extension of the drainage system. The purpose of the project is to remove excess water from the area to improve its agricultural value. Other benefits include 1) additional water for the waterfowl management area, 2) better distribution of water on Farmington Bay, 3) better control of flooding water, 4) more efficient mosquito control practices.

B. Wheeler Machinery Company Test Area

Planned construction of the waterfowl area is dependent upon availability of heavy construction equipment to be field tested and the personnel to operate the equipment. Preliminary land leveling and surveying for several fields and dikes in the waterfowl area has been accomplished, and it is likely that construction will start early in 1965.

C. Lake Front Gun, Fur and Reclamation Club

On the Lake Front Club 4,200 feet of dike were reconstructed with the use of a dragline. This dike is about 16 feet wide at the top and 10 feet high. A D-4 caterpillar was used to reinforce 4,000 feet of dike and to build 1,800 feet of new dike. These new dikes will aid immeasurably in maintaining stable water levels and in otherwise controlling the water on this marsh.

XII. PROPOSED PROGRAM OUTLINE AND RECOMMENDATIONS FOR 1965

A. Mosquito Surveys

1. Adult Counts

   a. Continue operating three light traps twice weekly during the mosquito season.

   b. Continue biting counts twice weekly at two stations. Make observations of environmental factors such as temperature, wind velocity, humidity, and light intensity at the time the bite counts are made.

2. Larval Surveys

   a. Continue when possible weekly sampling at the same stations used in 1964. Some of the sampling stations on the Wheeler Test Area are being eliminated through land development.

   b. Determine the area that will be covered by each measured rise in water level in a given area and the resulting mosquito production from the flooding that occurs.

   c. Compare the mosquito production in the flooding of different vegetative types.

   d. Establish sampling stations at Timpie Waterfowl Management Area, Tooele County, where no mosquito abatement program has been in operation, for comparison with areas in which abatement programs are in operation.

B. Wildlife Surveys

1. Continue nesting surveys.

2. Obtain adult bird count data from State Department of Fish and Game and also observe bird utilization of the sampling stations.

3. Make a muskrat survey including houses in the sampling stations and the trapping activities.

4. A fish survey including kinds, numbers, habitat, and economic potential would be desirable if the personnel for such a study can be obtained.

5. Continue a study of the kinds and relative abundance of amphibians and reptiles.

6. Make another vegetative survey for comparison with previous surveys.

C. Water Studies

1. Continue BOD, MPN coliforms, salinity, ion analysis and pH studies as in 1964.
2. Initiate a monitoring survey for insecticides in the water and study the role of insecticides in the aquatic environment.
3. Continue to utilize the Geological Survey quantitative measurements. Also make water level measurements including the change in extent of the area covered corresponding to measured water level changes.
4. Initiate a study of ground water, its seasonal fluctuations, its effect on vegetation, and its effect on the surface water.

D. Encephalitis Surveillance

Maintain the two sentinel flocks as in 1963-1964.

E. Weather

1. Continue the operation of the evaporation station at Farmington Bay Waterfowl Management Area.
2. Utilize weather and climate data from the Weather Bureau.

F. Crops

1. Observe the results of barley, tall wheatgrass, and white clover plantings on the Lake Front Gun Club.
2. Replant millet on the Lake Front Gun Club.
3. Observe the millet planting operations on the North Point Gun Club.
4. Observe and obtain data on planted crops from Farmington Bay Waterfowl Management Area.
5. Determine the abundance and value of natural crops in the study areas. These include those utilized by the wildlife and the commercial crops such as salt grass.

G. Land Development

Investigate the potential of the study areas for development from the standpoint of:

1. Recreational Development
    a. Fishing
    b. Boating

2. Industrial Development

3. Agricultural Development

4. Residential Development

H. Recommendations

1. Construction

   a. Urge and promote the construction of the Farmington Bay by-pass water channel.

   b. Establish roads and crossings on the Lake Front dikes to facilitate travel for inspection, mosquito control, water management, and dike repair.

   c. Reconstruct the dike in Area 1 of the Lake Front Club.

2. Wheeler Project

   Encourage and observe the development of the agriculture and waterfowl projects as outlined by the Soil Conservation Service.

3. Work with the Geological Survey to determine the consumptive use of water on the marsh areas.

4. Water Management

   a. Area 1, Lake Front Gun Club. Maintain a high water level during the spring and early summer months. When the water supply begins to decrease, withdraw the water rapidly from the salt grass area and prevent reflooding until after the middle of September.

   b. Area 2, Lake Front Gun Club. If the water supply is low in the mid-season, dry this area completely and prevent reflooding until after the middle of September.

   c. Areas 6, 7, 8, 9, and 10, Lake Front Gun Club. Maintain the water level as high as possible in the spring and early summer months. Allow a gradual drawdown in the summer as the water supply decreases and prevent reflooding of dry areas until after the middle of September.

   d. Areas 2, 3, and 5, Farmington Bay Waterfowl Management Area. Maintain the water level as high as possible during the spring and early summer. Allow a gradual drawdown as the water supply decreases and prevent reflooding until after the middle of September.

   e. Area 6, Farmington Bay. Dry as quickly as possible and control the cattails by burning or mechanical means. Reflood to sufficient depth to prevent cattail growth.

f. Area 7, Farmington Bay. Flood irrigate in the spring and summer as the water is available. Keep dry during the mid-season and reflood after the middle of September.

g. Area 8, Farmington Bay. Maintain the water level as high as possible during the spring and early summer months. Withdraw the water rapidly when the water supply decreases and prevent reflooding until after the middle of September.

h. Area 10, Farmington Bay. Keep this area inundated during the entire season.

i. Area 14, Farmington Bay. Keep this area inundated during the entire season. Some chemical vegetation control might be attempted to reduce the vegetation density.

j. Wheeler Machinery Company Test Area. Because of the uncertainty of the construction work on this area, it is difficult to recommend specific water management practices. These will be formulated fully when the construction work is completed.

Cooperation with the water and land users in developing management programs individually suited to the land purposes, soil and water capabilities, and available water will continue in each area.

XIII. CONCLUSIONS TO DATE

A. Mosquito Control and Wildlife Management

1. Not all parts of the marsh are mosquito producing and not all areas which produce mosquitoes are equal in productivity.

2. Not all marsh areas are equally suitable for wildlife production and management.

3. Some of the factors which affect mosquito production and distribution are the type and density of the vegetation, water depth, water fluctuation, water quality, climatic conditions, and the mosquito control measures applied.

4. These same factors affect the production and distribution of waterfowl and other wildlife.

5. Six species of mosquito larvae and seven species of adults have been collected in the study areas.

6. Vegetated areas from which the water is repeatedly removed and flooded are high in mosquito production, especially of *Aedes dorsalis*, a flood water mosquito. These areas are generally characterized by salt grass (*Distichlis stricta*) vegetation.

7. Salt grass areas shallowly flooded (4-8 inches) are also highly productive of *Culex* and *Culiseta*, the more permanent water mosquitoes, if the water remains for two weeks or more when climatic conditions and other requirements are suitable.

8. Salt grass that is flooded provides a hazardous habitat for duck nests and is of little value as food for ducks. Salt grass which is not flooded is used extensively and safely by ducks for nesting during the nesting season and without flooding, salt grass areas do not constitute a mosquito problem.

9. Mosquito production in emergent marsh plants such as *Scirpus olneyi*, *Scirpus acutus*, *Scirpus paludosus* and *Typha* sp. varies with the vegetative type and density, and the water depth, but it is generally lower than in the flooded salt grass.

10. These emergent marsh plants are used by waterfowl for nesting and food.

11. No mosquito production was found in the submergent vegetation (*Rupia maritima*, *Potamogeton pectinatus* and *Chara* sp.).

12. These submergent plants are used extensively for food by the waterfowl.

13. Water management practices such as water confinement, permanent impoundment, controlled water depth, controlled seasonal drawdown, permanent removal, and controlled flood irrigation can materially reduce mosquito production.

14. By water management, plants that are desirable for food, nesting, and cover can be greatly increased in number and more widely distributed on the units.

15. Water management practices for mosquito control are compatible with approved waterfowl management practices.

16. Physical facilities such as dikes, channels, drains, access roads, and adequate inlets and outlets are essential for proper water management. Modification of terrain through shore line improvement and deepening of ponds is also necessary in some areas to facilitate water management practices suitable for waterfowl and destructive for mosquitoes.

17. Mechanical or chemical control of vegetation may be desirable in some areas for both mosquito control and wildlife management.

18. A water management program suited to the multi-purpose objectives of the water on each unit and the requirements necessary to integrate and accomplish these objectives should be formulated by all persons who are concerned with the water and land use in a particular unit.

B. Mosquito Control and Irrigation

1. Productivity on agricultural land can be increased through draining, leveling, fertilization, and the application of proper amounts of water.

2. The above measures will reduce or eliminate mosquito production on agricultural land.

3. Adequate facilities for uniform and rapid distribution of the water over the unit to be irrigated are necessary for irrigation.

4. Adequate facilities for rapidly removing the surface water from the irrigated unit are also essential.

5. Adequate disposal of the irrigation run-off water is a necessary element of mosquito control.

C. Water

1. Quality

    a. Because of the high salinity and the sodium hazard, water flowing into the Lake Front Gun Club is of limited agricultural value except for use in growing salt tolerant plants. Endemic plants of value to waterfowl grow abundantly even though the water is of low quality. Data gathered indicate that waterfowl propagation is the most practical use of the water because of the saline conditions which exist in the soils adjacent to the Great Salt Lake.

    b. The waters flowing into the Wheeler Machinery Company Test area are of high quality and no restrictions are placed upon their use in agriculture.

    c. Effluents of the sewage treatment plants in Davis County are considered to have limited beneficial use without additional treatment. It should be noted that three of the plants will have the effluents chlorinated early in 1965. This should result in a considerable improvement in water quality of the effluents from these plants.

2. Quantity

    a. The water supply into the study area varies both on a seasonal and a yearly basis.

    b. This variation results from changes in the amount of precipitation and from the varying amounts used by prior water users.

    c. This extreme variation in the water supply is a necessary consideration in planning a water management program for mosquito control and waterfowl management.

D. Crops

1. Investigations pertaining to crop plantings in the research areas were partially successful. Information gained during 1964 should insure greater success in the plantings planned for 1965. The salinity of the water and the soil and the method of water application are critical factors in determining the success of crop plantings.

2. Crops which matured were readily utilized by waterfowl and other wildlife.

PART III

APPENDIX

TABLES AND FIGURES

REPORTS OF COLLABORATORS

SELECTED REFERENCES

PUBLICATIONS OF RESEARCH GRANT
WP-00027

Appendix Table 1

1964 SPECIES OF MOSQUITO LARVAE FOUND IN EACH SAMPLING STATION

Station Number	Aedes dorsalis	Culiseta inornata	Culex tarsalis	Culex erythrothorax	Culex pipiens	Culex salinarius	Total No. of Species
Lake Front Gun, Fur and Reclamation Club:							
1	X	X	X				3
2	X	X	X				3
6	X	X	X				3
7	X	X	X				3
8	X	X	X				3
9	X	X	X				3
10		X	X	X		X	4
Lake Front Total	6	7	7	1	0	1	5
Farmington Bay Waterfowl Management Area:							
2	X		X				2
3	X	X	X				3
5	X	X	X			X	4
6	X	X					2
7	X	X	X	X		X	5
8	X	X	X				3
10	X	X	X				3
14	X	X	X				3
Farmington Total	8	7	7	1	0	2	5
Wheeler Test Area:							
1							0
2A							0
2B	X	X	X				3
3	X	X	X				3
4	X		X		X		3
5							0
6			X				1
7	X	X					2
8		X	X	X			3
9	X		X				2
10			X				1
11	X	X	X				3
12	X	X	X				3
13			X				1
14	X						1
16	X	X	X				3
Wheeler Total	9	7	11	1	1	0	5
Total of 3 Areas	23	21	25	3	1	3	6

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Appendix Table 2

1964 NUMBER OF TIMES THE LARVAE OF EACH SPECIES WERE COLLECTED AT EACH STATION

Lake Front Gun, Fur and Reclamation Club

Collections made weekly.

Sampling Station	Aedes dorsalis	Culiseta inornata	Culex tarsalis	Culex erythrothorax	Culex pipiens	Culex salinarius	Unidentified	No. times samples were made	Total no. times larvae were found*
1	9	5	5					26	15
2	4	5	3				1	26	10
6	5	3	10					26	15
7	6	3	4					26	9
8	7	1	6					26	10
9	3	12	6				1	26	15
10	0	10	8	1		1		26	14
Total no. of times	34	39	42	1	0	1	2	182	88
Percentages	29	33	36	0.8	0	0.8	1.7		48%

Farmington Bay Waterfowl Management Area

Sampling Station	Aedes dorsalis	Culiseta inornata	Culex tarsalis	Culex erythrothorax	Culex pipiens	Culex salinarius	Unidentified	No. times samples were made	Total no. times larvae were found*
2	3		1					26	4
3	7	18	8					26	23
5	4	19	12			1		26	23
6	1	7					1	26	9
7	11	5	10	1		1	1	26	19
8	4	6	5				2	26	10
10	7	14	7					26	22
14	2	1	4					26	7
Total no. of times	39	70	47	1	0	2	4	208	117
Percentages	24	43	29	0.6	0	1.2	2.4		56%

*This figure is not the total of each row since in many samples more than one species of larvae was found.

Appendix Table 2
(continued)

1964 NUMBER OF TIMES THE LARVAE OF EACH SPECIES WERE COLLECTED AT EACH STATION
Collections Made Weekly

Wheeler Test Area

Sampling Station	Aedes dorsalis	Culiseta inornata	Culex tarsalis	Culex erythrothorax	Culex pipiens	Culex salinarius	Unidentified	No. times samples were made	Total no. times larvae were found*
1								28	0
2A								28	0
2B	6	1	2					28	7
3	3	3	1					28	5
4	3		5		1			28	7
5								28	0
6			5					28	5
7	5	1					1	28	6
8		6	7	2				28	9
9	3		4				1	28	7
10			4					28	4
11	5	1	10				1	28	16
12	8	1	1				2	28	10
13		4						28	4
14	1							28	1
16	2	2	1					28	4
Total no. of times	36	19	40	2	1	0	5	448	85
Percentages	35	18	39	2.	1.	0	5.	-	19%

*This figure is not the total of each row since in many samples more than one species of larvae was found.

Appendix Table 3

1964 WEEKLY COMPARISON OF THE NUMBER OF EACH SPECIES OF MOSQUITO LARVAE COLLECTED IN THE THREE STUDY AREAS

Lake Front Gun, Fur and Reclamation Club

Species	April			May				June				July					August				September				Oct.		Total
	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
A. dorsalis	468	25	1	5	87	5	1	0	0	0	0	0	0	0	0	394	56	113	0	4	0	0	0	11	32	12	1214
C. inornata	0	0	1	2	17	4	9	9	8	0	1	4	26	0	0	79	11	70	40	19	0	0	0	0	1	2	303
C. tarsalis	0	0	0	0	0	9	3	1	10	4	84	37	17	0	0	32	26	110	144	81	47	2	0	0	0	0	607
C. erythrothorax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
C. pipiens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. salinarius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Unidentified	0	0	0	0	0	3	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
TOTAL	468	25	2	7	104	21	14	11	18	4	85	43	43	0	0	505	93	293	184	106	47	2	0	11	34	14	2134

Farmington Bay Waterfowl Management Area

Species	April			May				June				July					August				September				Oct.		Total
	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
A. dorsalis	24	73	175	41	70	7	1	3	4	3	0	0	0	58	0	0	110	0	69	7	0	125	0	5	0	15	790
C. inornata	0	0	0	7	14	26	23	12	6	10	76	211	281	100	103	86	7	25	78	123	11	14	44	9	0	40	1306
C. tarsalis	0	0	0	0	0	21	16	4	9	2	63	152	203	186	126	90	12	51	36	5	0	48	11	0	0	2	1037
C. erythrothorax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. pipiens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
C. salinarius	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	6
Unidentified	31	0	0	0	0	13	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	51
TOTAL	55	73	175	48	84	67	40	19	20	15	139	363	484	347	232	176	129	76	183	135	11	187	55	14	0	65	3192

Appendix Table 3(Cont.)

1964 WEEKLY COMPARISON OF THE NUMBER OF EACH SPECIES
OF MOSQUITO LARVAE COLLECTED IN THE THREE STUDY AREAS

Wheeler Test Area

Species	April				May				June				July					August				September				Oct.		Total
	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
A.dorsalis	14	123	19	87	132	18	15	290	120	70	380	41	0	0	4	0	0	0	24	0	0	0	0	0	0	0	0	1337
C.inornata	0	0	0	0	0	0	5	4	22	0	3	3	1	0	20	0	0	0	0	0	0	11	12	13	9	45	0	148
C.tarsalis	0	1	0	0	0	0	2	8	18	0	2	25	6	0	112	29	59	35	75	135	110	113	62	96	68	31	34	1021
C.erythro-thorax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	7
C.pipiens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
C. salinarius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidenti-fied	0	0	2	0	0	0	17	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26
TOTAL	14	124	21	87	132	18	39	302	167	70	385	69	7	0	136	32	59	35	99	135	110	124	74	109	77	81	36	2542

Three Study Areas Combined

Species	April				May				June				July					August				September				Oct.		Total
	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
A.dorsalis	14	615	117	263	178	175	27	292	123	74	383	41	0	0	62	0	394	166	137	69	11	0	125	0	16	32	27	3341
C.inornata	0	0	0	1	9	31	35	36	43	14	13	80	216	307	120	103	165	18	95	118	142	22	26	57	18	46	42	1757
C.tarsalis	0	1	0	0	0	0	32	27	23	19	8	172	195	220	298	155	181	73	236	315	196	160	112	107	68	31	36	2665
C.erythro-thorax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	6	4	12
C.pipiens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
C. salinarius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	6
Unidenti-fied	0	31	2	0	0	0	33	1	8	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	84
TOTAL	14	647	119	264	187	206	127	356	197	108	404	293	413	527	483	264	740	257	468	502	351	182	263	164	102	115	115	7868

Appendix Table 4

1964 TOTAL MOSQUITO LARVAE COLLECTED IN WEEKLY COLLECTIONS, APRIL - OCTOBER

Lake Front Gun, Fur and Reclamation Club

Sampling Station	Total No. of Larvae	Aedes dorsalis		Culiseta inornata		Culex tarsalis		Culex pipiens		Culex erythrothorax		Culex salinarius		Unidentified	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	666	535	80	18	3	113	17	0	0	0	0	0	0	0	0
2	48	20	42	15	31	9	19	0	0	0	0	0	0	4	8
6	194	76	39	9	5	109	56	0	0	0	0	0	0	0	0
7	511	403	79	31	6	77	15	0	0	0	0	0	0	0	0
8	127	62	49	14	11	51	40	0	0	0	0	0	0	0	0
9	346	118	34	70	20	156	45	0	0	0	0	0	0	2	0.5
10	242	0	0	146	60	92	38	0	0	1	0.5	2	1	1	0.5
Total	2,134	1,214	57	303	14	607	28	0	0	1	.05	2	.1	7	.3

Farmington Bay Waterfowl Management Area

Sampling Station	Total No. of Larvae	Aedes dorsalis		Culiseta inornata		Culex tarsalis		Culex pipiens		Culex erythrothorax		Culex salinarius		Unidentified	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
2	10	9	90	0	0	1	10	0	0	0	0	0	0	0	0
3	638	220	34	313	49	105	16	0	0	0	0	0	0	0	0
5	474	29	6	352	74	90	19	0	0	0	0	3	0.6	0	0
6	25	3	12	21	84	0	0	0	0	0	0	0	0	1	4
7	472	217	46	21	4	223	47	0	0	2	0.4	3	0.6	6	1.3
8	846	93	11	354	42	355	42	0	0	0	0	0	0	44	5
10	469	216	46	235	50	18	4	0	0	0	0	0	0	0	0
14	258	3	1	10	4	245	95	0	0	0	0	0	0	0	0
Total	3,192	790	25	1,306	41	1,037	32	0	0	2	0.06	6	0.2	51	2

Appendix Table 4
(continued)

1964 TOTAL MOSQUITO LARVAE COLLECTED
IN WEEKLY COLLECTIONS, APRIL - OCTOBER

Wheeler Test Area

Sampling Station	Total No. of Larvae	Aedes dorsalis		Culiseta inornata		Culex tarsalis		Culex pipiens		Culex erythrothorax		Culex salinarius		Unidentified	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2B	260	248	95	2	0.8	10	4	0	0	0	0	0	0	0	0
3	103	47	46	26	25	27	26	3	3	0	0	0	0	0	0
4	84	6	7	0	0	78	93	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	51	0	0	0	0	51	100	0	0	0	0	0	0	0	0
7	202	193	96	5	2	0	0	0	0	0	0	0	0	4	2
8	361	0	0	106	29	248	69	0	0	7	2	0	0	0	0
9	258	180	70	0	0	76	29	0	0	0	0	0	0	2	1
10	34	0	0	0	0	34	100	0	0	0	0	0	0	0	0
11	900	420	47	4	0.4	459	51	0	0	0	0	0	0	17	2
12	118	109	92	3	3	3	3	0	0	0	0	0	0	3	3
13	32	0	0	0	0	32	100	0	0	0	0	0	0	0	0
14	11	11	100	0	0	0	0	0	0	0	0	0	0	0	0
16	128	123	96	2	2	3	3	0	0	0	0	0	0	0	0
Total	2,542	1,337	53	148	6	1,021	40	3	0.1	7	0.3	0	0	26	1

Appendix
Table 5

1962-1963-1964 WEEKLY COMPARISON OF MOSQUITO LARVA DENSITIES MEASURED IN NUMBER OF LARVAE PER DIP LAKE FRONT GUN, FUR AND RECLAMATION CLUB

Weeks	SAMPLING STATIONS																				
	1			2			6			7			8			9			10		
	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964
April 3	x	x	1.12	x	x	0	x	x	0.58	x	x	4.47	x	x	0.31	x	x	0	x	x	0
4	x	x	0.24	x	x	0	x	x	0	x	x	0.02	x	x	0	x	x	0	x	x	0
5	x	x	0	x	x	0	x	x	0	x	x	0	x	x	0.01	x	x	0.02	x	x	0
May 1	1.0	0.01	0	-	0.07	0	x	0.18	0	x	0.03	x	x	0.01	0.06	x	0.18	0.04	x	0.30	0
2	1.0	0.03	0.04	-	0	0.02	-	0.12	0.21	x	0.11	0.81	x	0	x	x	0.05	0.03	x	0.50	0.13
3	x	x	0.01	x	x	0	x	x	0.04	x	x	0.04	x	x	0.11	x	x	0	x	x	0
4	0.5	0.25	0	-	0.03	0.34	x	0.07	0.01	x	0.06	0	x	0.06	0.03	x	0.18	0.10	x	0.04	0.03
5	0.53	0.19	x	1.00	0.05	x	0.37	0	x	0.16	0	x	x	0	x	0.43	0.10	x	x	0.40	x
June 1	0.11	0.46	0	0.92	0.11	0.01	0.02	0.02	0.03	0.25	0	0	x	0.03	0	0.32	0.24	0.10	0.16	0.40	0.05
2	0.28	0.02	0.03	0.69	0.09	0.04	0.26	0.29	0.06	x	0	0	0.05	0	0	0.41	0.66	0.02	0.52	0.28	0.10
3	1.23	0.06	0.03	3.06	0.01	0.01	1.59	0.39	0	0.38	0.03	0	0.01	0.23	0	0.32	0.18	0	1.62	0.30	0
4	3.03	0.59	0.73	5.69	0	0	0.06	1.14	0	0.16	0.09	0	0.16	2.94	0	0.30	1.24	0.16	0.82	-	0.08
July 1	2.24	0.48	0.23	2.16	0.56	0	1.33	-	0.23	0.20	-	0	0.11	-	0	0.75	-	0.04	2.85	0.03	0
2	0	-	0.12	1.43	-	0.12	0	-	0.01	0.28	-	0	0.27	-	0	1.36	-	0	2.15	-	0.04
3	0	0	0	0	-	0	0	-	0	0.24	-	0	0.83	0	0	0.94	3.24	0	1.93	1.16	0
4	3.50	6.81	-	2.26	0.07	0	0.74	-	-	0.30	0.51	-	1.07	0.11	-	0.82	0.16	-	1.17	0.04	-
5	1.42	1.19	2.58	0.92	0.04	0.01	1.00	-	0.21	0.28	0.01	-	0.51	0	0.40	0.36	0.06	2.26	0.73	0.02	1.52
Aug. 1	0.09	2.48	0.24	0.03	0.28	0	0.70	0.07	0.06	0.29	0.08	0.60	0.03	0.03	0.06	0.74	0.84	0.38	0.37	0.38	0.18
2	3.53	0.40	1.11	0.28	0.17	-	2.08	-	0.21	0.19	-	0.68	0.21	0	0.15	0.40	0.04	1.76	0.55	0.11	0.56
3	0.11	0.20	-	0.92	0.13	-	0.46	0	0.45	0.04	0.07	0.72	2.27	0	0.11	0.76	0.24	0.84	0.37	0.04	1.18
4	0.27	0.15	-	0.24	0.19	-	4.14	-	0.13	1.14	-	0.80	0.54	0	0.04	0.28	0.54	0.60	0.03	0.14	0.42
Sept.1	0.60	0.62	-	0.08	0.10	-	0.12	-	0.08	0.34	-	0.08	0.43	-	-	0.52	0.52	0.52	0.23	0.32	0.20
2	1.05	0.42	-	0.09	0.24	-	0.14	2.48	-	0.15	1.53	-	0.29	0.30	-	0.20	0.28	-	0.03	0.14	0.04
3	0.45	0.86	-	0.03	0.17	-	0.87	1.45	-	0.16	0.73	-	0.01	0.07	-	0.02	0.44	-	0	0.26	0
4	0.10	0.45	0.03	0.01	0.05	0.08	0.75	1.05	0	0	0.41	0	0	0.05	0	0.02	0.40	0	0.37	0.14	0
Oct. 1	x	x	0.20	x	x	0.10	x	x	0.04	x	x	0	x	x	0	x	x	0.04	x	x	0.03
2	x	x	0.10	x	x	0.05	x	x	0	x	x	0	x	x	0	x	x	0	x	x	0
Overall Average Per Dip	1.16	0.63	0.30	1.10	0.14	0.02	0.82	0.62	0.10	0.26	0.27	0.42	0.40	0.11	0.07	0.49	0.49	0.29	0.77	0.27	0.02

- indicates station was dry. 0 indicates no larvae were found. x indicates no sample taken.

Appendix Table 6

1962-1963-1964 WEEKLY COMPARISON OF MOSQUITO LARVA DENSITIES MEASURED IN NUMBER OF LARVAE PER DIP FARMINGTON BAY WATERFOWL MANAGEMENT AREA

	SAMPLING STATIONS											
	2			3			5			6		
Weeks	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964
Apr. 3	x	x	0.3	x	x	0.17	x	x	0.02	x	x	0
4	x	x	0	x	x	0.56	x	x	0.10	x	x	0
5	x	x	0.13	x	x	1.20	x	x	0.22	x	x	0
May 1	x	0	0	x	0.08	0.14	x	0.40	0.23	x	0	0
2	x	0	0.02	x	0.11	0.10	x	0.76	0.23	x	0.12	0
3	x	0	0	x	0.63	0.05	x	0.40	0.29	x	0.01	0
4	x	0	0	x	0.10	0.06	0.22	0.06	0.27	0.03	0.03	0
5	0.02	0	x	0.28	0.12	x	0.48	0.05	x	0.96	0.77	x
June 1	0.26	0.3	0	3.43	0.40	0.80	0.31	2.43	0.16	8.24	0.32	0
2	4.50	0	0	4.34	0	0.14	0.73	2.20	0.02	4.70	3.60	0.01
3	0.30	0	0	10.90	0.40	0.06	2.0	0.12	0	2.72	12.21	0.01
4	0.06	0	0	10.17	1.36	0	0.10	0	0.45	2.97	0.05	0.01
July 1	0	-	0	2.0	0	0	0.90	0	0.36	0.76	-	0.02
2	0	-	0	8.30	0	0.96	0.60	0.02	0.60	1.27	-	0
3	1.23	-	-	12.15	3.50	0.83	3.50	0.10	1.19	4.06	0.32	0.08
4	1.08	-	-	3.45	10.10	1.34	0.32	0.18	0.80	0	8.66	0
5	1.44	-	-	25.6	11.40	1.62	1.12	0.40	0.51	0	1.80	0
Aug. 1	0.36	-	-	16.8	0	2.75	0	0	0.12	0	3.10	0.03
2	0.47	-	-	1.4	-	0.84	0.40	-	0.22	0	1.08	0
3	0.17	-	-	5.60	-	0.68	0	-	0.92	0.13	0.22	0
4	0.05	-	-	0.60	0	0.08	0.27	1.70	2.24	22.8	0.32	0
Sept. 1	0.03	-	-	0	30.25	0.17	0.13	1.30	0.25	18.33	0.52	0
2	0.02	-	-	0	25.0	0.06	0.50	0.80	0.01	8.22	0.68	0
3	0	0	0.25	0	1.69	0.29	1.03	0.25	0.17	4.54	0	0.10
4	x	x	-	x	0.29	0.06	x	0.14	0	x	0	0.02
Oct. 1	x	x	-	x	x	-	x	x	-	x	x	-
2	x	x	-	x	x	0.04	x	x	0.02	x	x	0.05
Overall Average Per Dip	0.54	0.04	.02	4.85	3.93	0.44	0.70	0.63	0.37	3.81	1.43	0.01

(Continued on next page)

- indicates station was dry.
0 indicates no larvae were found.
x indicates no sample taken.

Appendix Table 6
(Continued)

1962-1963-1964 WEEKLY COMPARISON OF MOSQUITO LARVA DENSITIES MEASURED IN NUMBER OF LARVAE PER DIP FARMINGTON BAY WATERFOWL MANAGEMENT AREA (CONTINUED)

Weeks	SAMPLING STATIONS											
	7			8			10			14		
	1962	1963	1964	1962	1963	1964	1962	1963	1964	1962	1963	1964
Apr. 3	x	x	0	x	x	0.31	x	x	0.10	x	x	0
4	x	x	0.11	x	x	0.16	x	x	0.08	x	x	0
5	x	x	0.26	x	x	0.53	x	x	0.09	x	x	0
May 1	x	0.01	0.21	x	0.12	0	x	0.01	0.04	x	0	0.03
2	x	0.16	0.75	x	0.12	0	x	0.02	0.33	x	0	0
3	x	0.30	0.19	x	0.16	0.19	x	0.03	0	x	0	0
4	0.58	0.20	0.01	x	0.12	0.39	x	0.11	0.05	x	0	0.13
5	2.29	0.11	x	0.41	0.37	x	0.31	0.12	x	x	0.04	x
June 1	0.11	0	0.04	3.92	0.89	0	0.21	0.03	0.02	x	0.18	0.01
2	2.06	0.55	0.06	2.50	2.56	0	0.43	0.01	0.01	x	0.08	0
3	0.31	0.33	0	2.36	5.88	0.85	0.75	0.44	0	x	0.24	0
4	0.07	0.26	0.75	6.56	6.27	0	0.71	0.05	0.50	2.20	1.24	0
July 1	0	0.08	0.11	4.98	-	2.11	1.23	-	1.17	1.60	0.39	0
2	0	0.06	0.02	0.52	-	2.95	0.44	-	0.91	5.88	0.30	0
3	0	0	0.62	0.80	-	1.59	1.31	-	0.73	0.84	0.10	0.87
4	0	-	0.09	0.60	-	-	0.16	-	0.08	1.30	0.04	0.88
5	0	0	0	0.80	-	0	1.04	-	0.04	2.10	0.02	0.74
Aug. 1	0	0	0	3.33	25.0	-	0	0	0.05	1.45	0	0.14
2	0	0	-	0	11.41	-	0.04	9.82	0.02	0.65	0.42	0
3	0	-	1.21	0	1.23	-	0.06	0.85	0.01	3.30	0	0
4	0.47	-	0.14	0	9.0	-	0	0.68	0.18	0.60	0	0
Sept. 1	0.15	-	0	0	4.27	-	0.07	0	0	1.45	0.16	0
2	0.03	-	1.24	0	7.50	-	0.04	0.08	1.56	1.10	0	0
3	0	0	0.20	0	6.54	-	0.07	0.20	0.01	0.67	0.02	0
4	x	0	0.08	x	0.26	0	x	0.31	0.04	x	x	0
Oct. 1	x	x	-	x	x	-	x	x	-	x	x	-
2	x	x	0.30	x	x	1.85	x	x	0.08	x	x	0
Overall Average Per Dip	0.91	0.20	0.03	2.48	2.09	0.50	0.48	0.25	0.22	1.76	0.19	1.21

- indicates station was dry.
0 indicates no larvae were found.
x indicates no sample taken.

Appendix Table 7

1963-1964 WEEKLY COMPARISON OF MOSQUITO LARVA DENSITIES MEASURED IN NUMBER OF LARVAE PER DIP, WHEELER MACHINERY COMPANY TEST AREA

Weeks	SAMPLING STATIONS															
	1		2A		2B		3		4		5		6		7	
	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964
Apr. 1	x	-	x	0	x	0	x	0	x	0	x	0	x	0	x	0
2	x	-	x	0	x	.21	x	0	x	.04	x	-	x	0	x	0
3	x	-	x	-	x	.06	x	0	x	.05	x	-	x	0	x	0
4	x	-	x	-	x	.05	x	0	x	0	x	-	x	0	x	0
5	x	-	x	0	x	0	x	0	x	0	x	0	x	0	x	0
May 1	-	-	0	0	0	.03	.23	0	0	0	0	0	.02	0	0	2.74
2	-	-	.02	0	0	0	.54	0	0	0	0	0	0	0	0	0
3	-	-	0	0	0	.08	.44	.24	0	0	0	0	0	0	0	0
4	-	-	0	0	0	0	.41	.04	0	.13	0	0	0	0	0	.89
5	-	x	0	x	0	x	.08	x	0	x	0	x	0	x	0	x
June 1	-	-	0	-	0	0	0	.89	0	.33	0	0	0	.20	.92	.78
2	-	-	.05	-	.10	4.63	0	0	0	0	0	0	0	0	.04	.09
3	-	-	2.55	-	.03	1.27	0	.58	0	0	0	0	.54	0	0	1.40
4	-	-	-	-	.04	-	.03	0	0	1.2	0	0	.02	.50	0	2.50
July 1	-	-	-	-	-	-	0	0	0	0	0	0	0	.20	12.5	-
2	-	-	-	-	-	-	0	0	0	0	0	0	0	.74	-	-
3	-	-	-	-	-	-	0	1.62	.03	0	0	0	.40	0	-	-
4	-	-	-	-	-	-	0	0	.05	.46	0	0	.80	.31	-	-
5	-	-	-	-	-	-	0	0	0	.40	0	0	0	0	-	-
Aug. 1	-	-	-	-	-	-	0	0	.16	0	0	0	0	0	-	-
2	-	-	-	-	-	-	0	0	.10	0	0	0	0	0	-	-
3	-	-	-	-	-	-	0	0	0	0	0	0	0	0	-	-
4	-	-	-	-	-	-	0	0	-	0	0	0	0	0	-	-
Sept. 1	-	-	-	-	-	-	0	0	0	0	0	0	0	0	-	-
2	-	-	-	-	-	-	0	0	0	0	0	0	0	0	-	-
3	-	-	-	-	-	-	0	0	.05	0	0	0	0	0	.16	-
4	-	-	-	-	-	-	0	-	-	0	0	0	-	0	4.33	-
Oct. 1	x	-	x	-	x	-	x	-	x	0	0	0	x	0	x	-
2	x	-	x	-	x	-	x	-	x	0	0	0	x	0	x	-
Overall Average Per Dip	0	0	.20	0	.02	.56	.18	.14	.01	.10	0	0	.09	.04	1.78	.63

- indicates station was dry.
x indicates no sample was taken.
0 indicates no larvae were found.

(Continued on next page)

Appendix Table 7
(continued)

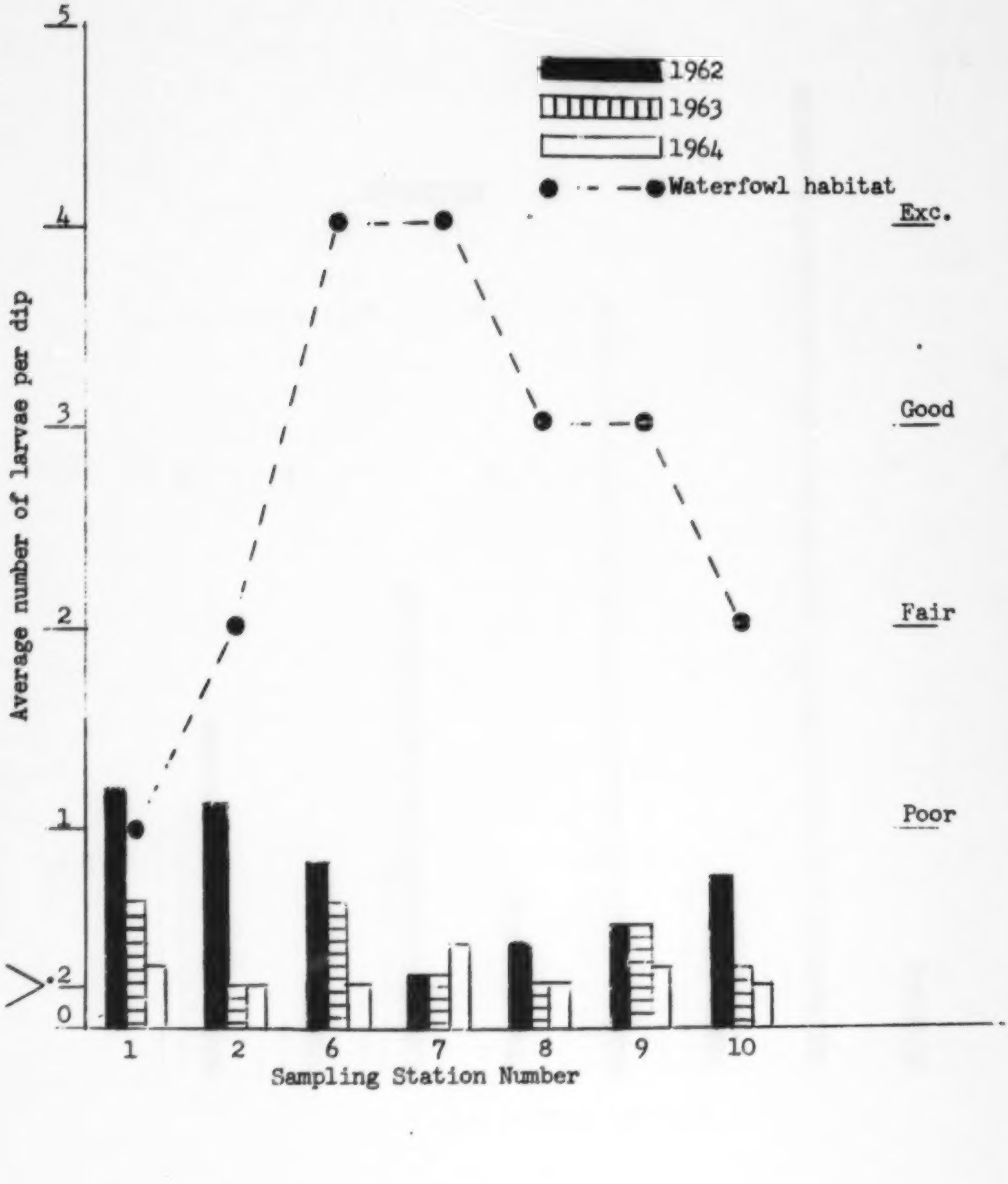
1963-1964 WEEKLY COMPARISON OF MOSQUITO LARVA DENSITIES MEASURED IN NUMBER OF LARVAE PER DIP, WHEELER MACHINERY COMPANY TEST AREA
(CONTINUED)

Weeks		SAMPLING STATIONS																	
		8		9		10		11		12		13		14		15		16	
		1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964	1963	1964
Apr.	1	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x		x	0
	2	x	0	x	0	x	0	x	0	x	.04	x	0	x	0	x		x	0
	3	x	0	x	4.0	x	0	x	.04	x	0	x	0	x	0	x		x	0
	4	x	0	x	.08	x	0	x	0	x	.71	x	0	x	0	x		x	0
	5	x	0	x	1.0	x	0	x	.88	x	.67	x	0	x	.04	x		x	0
May	1	.17	0	0	0	0	0	0	1.06	0	.80	0	0	0	0	-		.48	0
	2	.14	0	0	0	0	0	.02	.52	0	.33	0	0	0	0	-		0	0
	3	0	0	0	0	0	0	0	.55	0	.56	0	0	0	0	-		0	0
	4	0	0	0	0	0	0	0	2.50	0	.56	0	0	0	0	-		0	0
	5	0	x	0	x	0	x	0	x	0	x	0	x	0	x	-		0	x
June	1	.02	0	0	0	0	0	0	0	0	.07	0	0	0	0	0	NOT SAMPLED	13.33	0
	2	1.50	0	0	0	0	0	0	5.0	0	.03	0	0	0	0	0		3.0	0
	3	.20	0	.24	0	0	0	.70	0	4.81	0	0	0	0	0	0		.7	.30
	4	1.86	0	.16	0	0	0	0	0	1.45	2.0	0	0	0	0	0		1.67	8.0
July	1	1.05	0	.04	0	0	0	-	0	.09	0	-	0	-	0	0		.45	.05
	2	-	0	0	0	0	0	-	0	0	0	-	0	-	0	0		0	.27
	3	-	4.40	0	.30	0	.01	-	0	0	0	-	0	-	0	0		.73	-
	4	8.0	0	0	0	0	.03	-	0	0	-	-	0	-	0	0		.90	-
	5	-	0	-	0	0	.67	-	0	0	-	-	.13	-	0	0		2.5	-
Aug.	1	0	.70	-	.87	0	0	-	0	-	-	-	0	-	0	0		.5	-
	2	-	.25	-	5.0	0	0	-	.53	-	-	-	0	-	0	-		1.13	0
	3	0	0	-	0.23	0	0	-	6.3	-	-	-	0	-	0	-		.45	0
	4	-	0	-	0	0	0	-	7.85	-	-	-	0	-	0	-		3.6	0
Sept.	1	-	2.60	-	0	.88	0	-	2.77	-	-	-	.40	-	0	-		2.75	-
	2	0	1.0	-	0	12.0	0	-	1.36	-	-	-	.80	-	0	-		1.50	-
	3	.20	6.25	0	0	1.93	0	-	0.33	0	-	0	.10	0	0	0		.42	-
	4	-	1.75	-	0	1.35	.02	-	2.11	-	-	-	0	-	0	-		-	-
Oct.	1	x	2.0	x	0	0	0	x	1.72	x	-	x	0	x	0	x		x	-
	2	x	.08	x	0	0	0	x	1.21	x	-	x	0	x	0	x		x	-
Overall Average Per Dip		.56	.53	.03	.43	.96	.03	.08	1.65	.54	.32	0	.05	0	.02	0		1.34	.421

- indicates station was dry.   0 indicates no larvae were found.   x indicates no sample was taken.

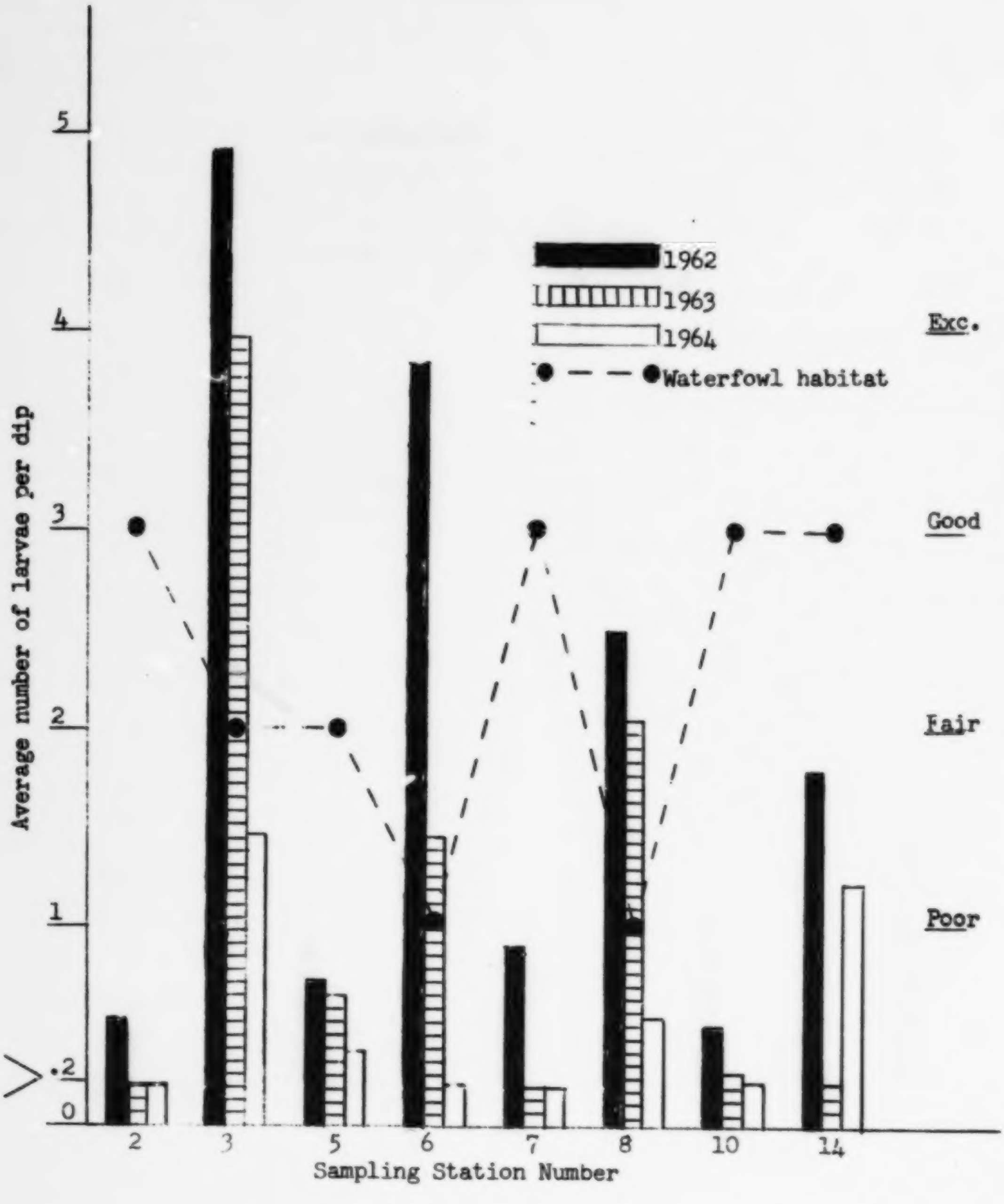
Appendix Figure 1

MOSQUITO LARVAE DENSITIES
LAKE FRONT GUN, FUR AND RECLAMATION CLUB



Appendix Figure 2

MOSQUITO LARVAE DENSITIES
FARMINGTON BAY WATERFOWL MANAGEMENT AREA



Appendix Table 8

1964 - THE NUMBER OF TIMES MOSQUITO LARVAE WERE COLLECTED, COMPARED BY AVERAGE NUMBER PER DIP

Lake Front Gun, Fur and Reclamation Club

Station	Number of mosquitoes per dip									Total no. of times larvae found	Total no. of times station sampled
	Less than 0.1	0.1 to 0.5	0.51 to 1.0	1.1 to 2.0	2.1 to 3.0	3.1 to 4.0	4.1 to 5.0	5.1 to 10.0	Over 10.0		
1	5	6	1	2	1	0	0	0	0	15	26
2	7	3	0	0	0	0	0	0	0	10	26
6	8	6	1	0	0	0	0	0	0	15	26
7	3	0	5	0	0	0	1	0	0	9	26
8	5	5	0	0	0	0	0	0	0	10	26
9	6	4	3	1	1	0	0	0	0	15	26
10	6	5	1	2	0	0	0	0	0	14	26
TOTAL	40	29	11	5	2	0	1	0	0	88	182

Farmington Bay Waterfowl Management Area

Station	Number of mosquitoes per dip									Total no. of times larvae found	Total no. of times station sampled
	Less than 0.1	0.1 to 0.5	0.51 to 1.0	1.1 to 2.0	2.1 to 3.0	3.1 to 4.0	4.1 to 5.0	5.1 to 10.0	Over 10.0		
2	1	3	0	0	0	0	0	0	0	4	26
3	7	6	6	3	1	0	0	0	0	23	26
5	4	13	4	1	1	0	0	0	0	23	26
6	8	1	0	0	0	0	0	0	0	9	26
7	6	8	3	2	0	0	0	0	0	19	26
8	0	4	2	2	2	0	0	0	0	10	26
10	14	4	2	2	0	0	0	0	0	22	26
14	2	2	3	0	0	0	0	0	0	7	26
TOTAL	42	41	20	10	4	0	0	0	0	117	208

Appendix Table 8
(Continued)

1964 - THE NUMBER OF TIMES MOSQUITO LARVAE WERE COLLECTED, COMPARED BY AVERAGE NUMBER PER DIP

Wheeler Machinery Company Test Area

Station	Number of mosquitoes per dip									Total no. of times larvae found	Total no. of times station sampled
	Less than 0.1	0.1 to 0.5	0.51 to 1.0	1.1 to 2.0	2.1 to 3.0	3.1 to 4.0	4.1 to 5.0	5.1 to 10.0	Over 10.0		
1	0	0	0	0	0	0	0	0	0	0	28
2A	0	0	0	0	0	0	0	0	0	0	28
2B	4	1	0	1	0	0	1	0	0	7	28
3	1	1	2	1	0	0	0	0	0	5	28
4	2	4	0	1	0	0	0	0	0	7	28
5	0	0	0	0	0	0	0	0	0	0	28
6	0	4	1	0	0	0	0	0	0	5	28
7	1	0	2	1	2	0	0	0	0	6	28
8	1	1	2	2	1	0	1	1	0	9	28
9	1	2	2	0	0	1	1	0	0	7	28
10	3	0	1	0	0	0	0	0	0	4	28
11	1	1	4	4	2	0	1	2	1	16	28
12	3	1	5	1	0	0	0	0	0	10	28
13	0	3	1	0	0	0	0	0	0	4	28
14	1	0	0	0	0	0	0	0	0	1	28
15			NOT SAMPLED								0
16	1	2	0	0	0	0	0	1	0	4	28
TOTAL	19	20	20	11	5	1	4	4	1	85	448

Appendix Table 9

1962-1963-1964 COMPARISON OF *AVERAGE WEEKLY LIGHT TRAP COLLECTIONS

Farmington Bay Waterfowl Management Area

Species		May				June				July					August				September				Oct.		TOTAL
		2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	-	4	12	-	11	10	3	-	11	31	6	37	37	60	11	19	5	18	118	7	53	17	36	506
	1963	-	-	-	0	5	6	109	-	12	16	2	15	15	16	34	16	28	5	69	14	38	-	-	400
	1964	7	23	11	-	33	5	32	-	-	11	21	-	13	21	14	7	6	30	15	8	3	3	1	264
Culiseta inornata	1962	-	17	86	-	47	82	6	-	73	45	10	61	20	46	11	20	32	22	16	16	46	33	19	708
	1963	-	-	-	11	20	50	40	-	5	4	3	20	6	3	10	1	9	2	4	7	40	-	-	235
	1964	6	2	1	-	3	2	6	-	-	3	12	-	22	48	32	18	1	2	2	6	1	0	0	67
Culex tarsalis	1962	-	7	51	-	25	38	4	-	21	48	141	468	368	443	180	101	152	210	125	126	207	232	54	3001
	1963	-	-	-	13	8	35	26	-	6	16	12	30	12	8	21	4	30	1	14	13	123	-	-	372
	1964	3	0	1	-	5	39	33	-	-	27	6	-	21	34	19	9	14	13	6	3	6	11	4	254
Culex pipiens	1962	-	0	0	-	1	0	0	-	0	4	0	4	2	0	3	0	1	1	1	0	0	1	0	18
	1963	-	-	-	0	0	0	0	-	0	0	0	0	0	0	0	0	3	0	0	0	0	-	-	3
	1964	2	0	0	-	1	0	2	-	-	1	2	-	1	7	2	0	0	0	0	0	0	0	0	18
Culex erythrothorax	1962	-	0	0	-	0	0	0	-	0	0	5	12	13	10	22	1	3	23	26	26	37	29	9	216
	1963	-	-	-	2	1	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	1	-	-	4
	1964	0	0	0	-	1	0	0	-	-	0	0	-	0	1	1	10	20	7	3	3	4	3	0	53
Anopheles freeborni	1962	-	0	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	-	-	-	0	0	0	0	-	1	0	0	0	0	0	0	0	0	0	0	0	0	-	-	1
	1964	0	0	0	-	0	0	0	-	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0
Aedes nigromaculis	1962	-	0	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	-	-	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0	1	0	0	0	-	-	1
	1964	0	0	0	-	0	0	0	-	-	0	0	-	0	2	0	0	0	0	0	0	0	0	0	2
Unidentified	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1962	-	28	149	-	84	130	13	-	105	128	162	582	440	559	227	141	193	274	286	175	343	312	118	4449
	1963	-	-	-	26	34	91	175	-	24	36	17	65	33	27	65	21	70	9	87	34	202	-	-	1016
	1964	18	25	13	-	43	46	73	-	-	42	41	-	57	113	68	44	41	52	26	20	14	17	5	758

* Total number collected per week divided by total collections per week.

Appendix Table 9
(Continued)

1962-1963-1964 COMPARISON OF *AVERAGE WEEKLY LIGHT TRAP COLLECTIONS

South Davis Sewage Treatment Plant

Species		May				June				July					August				September				Oct.		TOTAL
		2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	-	0	0	-	0	5	2	3	2	14	2	3	65	5	116	17	1	26	9	81	16	-	-	367
	1963	-	-	-	12	3	7	142	42	16	38	5	27	85	129	96	2	43	102	43	37	-	307	1	1136
	1964	0	1	0	-	4	14	28	8	30	3	26	18	24	65	100	9	5	5	3	49	11	18	16	437
Culiseta inornata	1962	-	3	5	-	7	47	62	60	57	135	27	132	62	39	103	42	5	70	8	51	16	-	-	931
	1963	-	-	-	64	50	133	306	49	30	203	25	156	75	155	89	2	63	27	11	9	-	19	-	1466
	1964	1	0	0	-	2	10	43	33	49	51	409	40	173	130	208	19	20	9	20	15	0	1	1	1234
Culex tarsalis	1962	-	0	1	-	2	4	4	7	14	82	17	39	289	14	62	46	1	20	1	17	3	-	-	623
	1963	-	-	-	14	7	27	26	7	27	95	16	73	90	62	70	2	90	30	21	8	-	27	-	692
	1964	0	0	0	-	1	10	50	30	32	14	131	38	177	169	197	25	13	5	4	7	0	3	1	907
Culex pipiens	1962	-	0	0	-	0	0	0	0	0	3	1	0	4	1	3	0	0	1	1	5	2	-	-	21
	1963	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	-	0	-	2
	1964	0	0	0	-	0	0	0	0	0	0	0	1	6	8	8	2	2	0	0	0	0	0	0	27
Culex erythrothorax	1962	-	0	0	-	0	0	0	0	0	0	0	2	6	0	3	4	0	3	3	6	1	-	-	28
	1963	-	-	-	2	0	0	3	0	0	0	0	1	0	0	0	0	0	0	1	1	-	5	-	13
	1964	0	0	0	-	0	0	0	0	1	0	2	2	14	24	8	12	10	2	15	4	1	0	1	96
Anopheles freeborni	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
	1963	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	-	0
	1964	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aedes nigromaculis	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
	1963	-	-	-	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	1	3	-	0	-	8
	1964	0	0	0	-	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2
Unidentified	1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1962	-	3	6	-	9	56	68	70	73	234	47	176	426	59	287	109	7	120	22	160	38	-	-	1970
	1963	-	-	-	92	60	167	478	98	73	336	46	257	250	346	255	6	196	162	78	59	-	358	-	3317
	1964	1	1	0	-	7	34	121	71	112	68	568	100	394	397	521	67	50	21	42	75	12	22	19	2703

* Total number collected per week divided by total collections per week.

Appendix Table 9
(Continued)

1962-1963-1964 COMPARISON OF *AVERAGE WEEKLY LIGHT TRAP COLLECTIONS

Davis County M A D Field Office, Kaysville

Species		May				June				July					August				September				Oct.		TOTAL
		2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	2	1	2	3	4	1	2	
Aedes dorsalis	1962	-	1	0	-	0	2	1	1	1	2	2	7	10	2	1	0	0	0	0	-	-	-	-	30
	1963	-	0	0	0	0	2	0	0	0	0	0	-	-	2	6	0	0	-	1	0	2	6	-	19
	1964	1	3	2	-	4	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	14
Culiseta inornata	1962	-	15	9	-	7	115	26	53	31	40	20	29	53	16	25	27	5	7	9	-	-	-	-	487
	1963	-	1	5	6	3	1	0	0	0	0	0	-	-	9	3	0	1	-	3	0	0	10	-	42
	1964	0	0	0	1	1	0	0	4	0	0	2	1	1	4	0	0	1	1	2	2	1	1	1	23
Culex tarsalis	1962	-	3	3	-	1	8	117	65	44	89	72	125	535	141	385	172	41	20	61	-	-	-	-	1882
	1963	-	1	0	0	3	0	0	0	0	0	0	-	-	8	39	25	35	-	90	50	50	151	-	452
	1964	0	0	0	0	0	1	7	7	7	49	0	18	12	65	48	29	15	9	21	35	51	21	8	403
Culex pipiens	1962	-	0	0	-	0	0	0	1	2	0	0	0	2	0	1	0	0	0	0	-	-	-	-	6
	1963	-	0	0	0	0	0	0	0	0	0	0	-	-	17	0	0	0	-	3	0	0	0	-	20
	1964	0	0	0	0	0	0	0	0	0	4	19	1	0	11	1	1	0	5	8	3	7	1	2	63
Culex erythrothorax	1962	-	0	0	-	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	-	-	-	-	4
	1963	-	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	-	1	0	1	1	-	3
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	2	1	2	9
Anopheles freeborni	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	-	-	-	-	1
	1963	-	0	0	0	0	0	0	0	0	0	0	-	-	0	0	0	0	-	0	1	0	0	-	1
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aedes nigromaculis	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	0
	1963	-	0	0	0	0	0	0	0	0	0	0	-	-	0	0	1	0	-	0	0	0	0	-	1
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	0
	1963	-	0	0	0	0	0	126	58	28	24	9	-	-	0	0	0	0	-	0	0	0	0	-	245
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1962	-	19	12	-	8	125	144	120	80	131	94	161	600	159	412	200	47	28	70	-	-	-	-	2410
	1963	-	2	5	6	6	3	126	58	28	24	9	-	-	36	48	26	36	-	98	51	53	168	-	783
	1964	1	3	2	1	5	1	7	12	7	53	21	21	14	80	49	30	16	16	34	41	61	24	13	512

* Total number collected per week divided by total collections per week.

Appendix Table 10

1962-1963-1964 COMPARISON OF AVERAGE* WEEKLY LIGHT TRAP COLLECTIONS
THREE STATIONS COMBINED

Species		May				June				July					August				September				Oct.		TOTAL
		2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	-	5	12	-	11	17	6	4	14	47	10	47	112	67	128	36	6	44	127	88	69	17	36	903
	1963	-	0	0	12	8	15	251	42	28	54	7	42	100	147	136	18	71	107	113	51	40	313	-	1555
	1964	8	27	13	-	41	19	60	9	30	14	47	19	38	86	114	16	11	35	19	57	14	21	17	715
Culiseta inornata	1962	-	35	100	-	61	244	94	113	161	220	57	222	135	101	139	89	42	99	33	67	62	33	19	2126
	1963	-	1	5	81	73	184	346	49	35	207	28	176	81	167	102	3	73	29	18	16	40	29	-	1743
	1964	7	2	1	1	6	12	49	37	49	54	423	41	196	182	240	37	22	12	24	23	2	2	2	1424
Culex tarsalis	1962	-	10	55	-	28	50	125	72	79	219	230	632	1192	598	627	319	194	250	187	143	210	232	54	5506
	1963	-	1	0	27	18	62	52	7	33	111	28	103	102	78	130	31	155	31	125	71	173	178	-	1516
	1964	3	0	1	0	6	50	90	37	39	90	137	56	210	268	264	63	42	27	31	45	57	35	13	1564
Culex pipiens	1962	-	0	0	-	1	0	0	1	2	7	1	4	8	1	7	0	1	2	2	5	2	1	0	45
	1963	-	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	3	0	4	1	0	0	-	25
	1964	2	0	0	0	1	0	2	0	0	5	21	2	7	26	11	3	2	5	8	3	7	1	2	108
Culex erythrothorax	1962	-	0	0	-	0	0	0	0	2	0	5	14	19	10	25	5	4	27	29	32	38	29	9	248
	1963	-	0	0	4	1	0	3	0	0	0	0	1	0	0	0	0	0	0	2	1	2	6	-	20
	1964	0	0	0	0	1	0	0	0	1	0	2	2	14	25	9	22	30	10	20	8	7	4	3	158
Anopheles freeborni	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	1963	-	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	-	2
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aedes nigromaculis	1962	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	-	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	4	1	3	0	0	-	10
	1964	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	4
Unidentified	1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1963	-	0	0	0	0	0	126	58	28	24	9	-	-	0	0	0	0	0	0	0	0	0	-	245
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1962	-	50	167	-	101	311	225	190	258	493	303	919	1466	777	926	450	247	422	378	335	381	312	118	8829
	1963	-	2	5	124	100	261	779	156	125	396	72	322	283	409	368	53	302	171	263	144	255	526	-	5116
	1964	20	29	15	1	55	81	201	83	119	163	630	121	465	590	638	141	107	89	102	136	87	63	37	3973

* Total number collected per week divided by total collections per week.

Appendix Table 11

1962-1963-1964 COMPARISON OF AVERAGE* WEEKLY COLLECTIONS OF BITING MOSQUITOES
FARMINGTON BAY WATERFOWL MANAGEMENT AREA

Species		June		July					August				September				Oct.		Total
		3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	94	0	1	42	2	10	56	4	10	5	7	38	60	33	36	-	-	398
	1963	-	-	-	-	-	11	54	7	20	10	10	5	7	39	-	-	-	163
	1964	94	61	74	57	171	79	-	42	85	33	66	49	58	66	106	30	34	1105
Culiseta inornata	1962	24	0	2	28	1	3	8	16	5	0	2	1	0	0	0	-	-	90
	1963	-	-	-	-	-	32	52	9	4	1	9	13	1	1	-	-	-	122
	1964	4	19	62	27	27	9	1	26	12	4	0	5	4	1	0	0	0	196
Culex tarsalis	1962	6	0	0	14	14	6	12	2	24	6	5	6	4	0	0	-	-	99
	1963	-	-	-	-	-	2	4	1	1	0	1	0	0	0	-	-	-	9
	1964	32	10	17	20	19	16	-	72	44	10	8	10	13	0	0	0	0	271
Culex pipiens	1962	0	0	0	0	0	0	1	0	0	0	0	0	2	1	0	-	-	4
	1963	-	-	-	-	-	0	0	0	0	0	0	0	0	0	-	-	-	0
	1964	0	1	0	0	0	0	-	0	2	0	0	0	0	0	0	0	0	3
Culex erythrothorax	1962	4	0	0	0	0	1	1	0	0	0	0	22	51	20	20	-	-	119
	1963	-	-	-	-	-	1	1	0	0	0	1	0	0	0	-	-	-	3
	1964	0	1	2	0	1	0	-	86	9	7	4	1	3	2	1	1	2	120
Aedes nigromaculis	1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
	1963	-	-	-	-	-	0	0	0	0	0	0	0	1	0	-	-	-	1
	1964	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1962	128	0	3	84	17	20	78	22	39	11	14	67	117	54	56	-	-	710
	1963	-	-	-	-	-	46	111	17	25	11	21	18	9	40	-	-	-	298
	1964	130	92	155	100	218	104	-	226	152	54	78	65	78	69	107	31	36	1695

- = No sample made.
0 = No mosquitoes taken.

*Total number collected per week divided by the total collections per week.

Appendix Table 11
(continued)

1962-1963-1964 COMPARISON OF AVERAGE* WEEKLY COLLECTIONS OF BITING MOSQUITOES
SOUTH DAVIS SEWAGE TREATMENT PLANT

Species		June		July					August				September				Oct.		Total
		3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	-	11	52	-	4	-	22	94	2	4	28	41	329	26	0	-	-	613
	1963	-	-	-	-	-	61	105	81	147	6	30	39	42	208	54	-	-	773
	1964	23	25	101	145	8	95	-	120	108	17	127	106	35	74	109	38	39	1170
Culiseta inornata	1962	-	0	132	-	10	-	1	30	0	4	4	0	0	0	0	-	-	181
	1963	-	-	-	-	-	25	11	9	4	0	3	4	0	3	12	-	-	71
	1964	2	6	34	28	20	7	-	23	13	2	11	13	14	0	0	0	0	173
Culex tarsalis	1962	-	0	5	-	4	-	0	2	0	2	2	0	0	0	246	-	-	261
	1963	-	-	-	-	-	53	48	19	15	1	9	3	0	2	25	-	-	175
	1964	5	12	18	39	4	28	-	41	47	16	13	14	30	1	4	0	0	272
Culex pipiens	1962	-	6	0	-	0	-	0	0	0	0	0	0	0	0	0	-	-	6
	1963	-	-	-	-	-	4	0	0	0	0	0	0	0	0	0	-	-	4
	1964	0	0	1	0	0	0	-	0	1	0	2	0	3	1	0	0	0	8
Culex erythrothorax	1962	-	1	0	-	1	-	2	0	0	0	0	64	2	0	0	-	-	70
	1963	-	-	-	-	-	3	1	1	0	0	1	1	1	0	2	-	-	10
	1964	0	0	1	3	0	4	-	8	7	1	4	3	5	1	1	2	18	58
Aedes nigromaculis	1962	-	0	0	-	0	-	0	0	0	0	0	0	0	0	0	-	-	0
	1963	-	-	-	-	-	0	0	0	0	0	0	3	0	1	1	-	-	5
	1964	0	0	0	1	0	1	-	0	0	2	0	0	0	0	0	0	0	4
TOTAL	1962	-	18	189	-	19	-	25	126	2	10	34	105	331	26	246	-	-	1131
	1963	-	-	-	-	-	146	165	110	166	7	43	50	43	214	94	-	-	1038
	1964	30	43	155	216	32	135	-	192	176	38	157	136	87	77	114	40	57	1685

- = No sample made.
0 = No mosquitoes taken.

*Total number collected per week divided by the total collections per week.

Appendix Table 12

1962-1963-1964 COMPARISON OF AVERAGE* WEEKLY COLLECTIONS OF BITING MOSQUITOES AT TWO STATIONS COMBINED

Species		June		July					August				September				Oct.		Total
		3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	
Aedes dorsalis	1962	94	11	53	42	6	10	78	98	12	9	35	79	389	59	36	-	-	1011
	1963	-	-	-	-	-	72	159	88	167	16	40	44	49	247	54	-	-	936
	1964	117	86	175	202	179	174	-	162	193	50	193	155	93	140	215	68	73	2275
Culiseta inornata	1962	24	0	134	28	11	3	9	46	5	4	6	1	0	0	0	-	-	271
	1963	-	-	-	-	-	57	63	18	8	1	12	17	1	4	12	-	-	193
	1964	6	25	96	55	47	16	-	49	25	6	11	18	18	1	0	0	0	369
Culex tarsalis	1962	6	0	5	14	18	6	12	4	24	8	7	6	4	0	246	-	-	360
	1963	-	-	-	-	-	55	52	20	16	1	10	3	0	2	25	-	-	184
	1964	37	22	35	59	23	44	-	113	91	26	21	24	43	1	4	0	0	543
Culex pipiens	1962	0	6	0	0	0	0	1	0	0	0	0	0	2	1	0	-	-	10
	1963	-	-	-	-	-	4	0	0	0	0	0	0	0	0	0	-	-	4
	1964	0	1	1	0	0	0	-	0	3	0	2	0	3	1	0	0	0	11
Culex erythrothorax	1962	4	1	0	0	1	1	3	0	0	0	0	86	53	20	20	-	-	189
	1963	-	-	-	-	-	4	2	1	0	0	2	1	1	0	2	-	-	13
	1964	0	1	3	3	1	4	-	94	16	8	8	4	8	3	2	3	20	178
Aedes nigromaculis	1962	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	0
	1963	-	-	-	-	-	0	0	0	0	0	0	3	1	1	1	-	-	6
	1964	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	4
TOTAL	1962	128	18	192	84	36	20	103	148	41	21	48	172	448	80	302	-	-	1841
	1963	-	-	-	-	-	192	276	127	191	18	64	68	52	254	94	-	-	1336
	1964	160	135	310	316	250	239	-	418	328	92	235	201	165	146	221	71	93	3380

- = No sample made.
0 = No mosquitoes taken.

* Total number collected per week divided by the total collections per week.

Appendix Table 13

1964 MAXIMUM NUMBER OF MOSQUITOES TAKEN IN ONE NIGHT IN LIGHT TRAP AND BITE COUNT COLLECTIONS

Week	LIGHT TRAP			BITE COUNT	
	Farmington Bay Waterfowl Management Area	South Davis Sewage Treatment Plant	Davis County MAD Field Office, Kaysville	Farmington Bay Waterfowl Management Area	South Davis Sewage Treatment Plant
April 1			0		
2			0		
3			1		
4			1		
5			3		
May 1			0		
2	18	1	0		
3	25	1	4		
4	23	0	6		
June 1	56	7	5		
2	46	51	1	65	30
3	119	120	11	94	43
4	361	71	11	264	165
July 1	-	112	9	46	153
2	48	68	51	182	285
3	41	189	30	251	32
4	48	102	31	104	135
5	59	394	16	-	-
Aug. 1	182	633	112	113	262
2	83	521	57	113	201
3	55	74	55	97	68
4	78	74	21	39	157
Sept. 1	94	17	42	75	112
2	26	41	36	121	128
3	20	103	76	93	84
4	19	12	86	184	84
Oct. 1	27	22	40	57	51
2	5	18	12	40	70

Appendix Table 14

1964 SUMMARY OF ALL MOSQUITOES COLLECTED

Lake Front Gun, Fur and Reclamation Club

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis	1214	57				
Culiseta inornata	303	14				
Culex tarsalis	607	28				
Culex erythrothorax	1	0.05	NONE	NONE	NONE	NONE
Culex pipiens	0	0				
Culex salinarius	2	0.1				
Anopheles freeborni	0	0				
Aedes nigromaculis	0	0				
Unidentified	7	0.3				
TOTAL	2134					

Farmington Bay Waterfowl Management Area

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis	790	25	1105	65	264	35
Culiseta inornata	1306	41	196	12	167	22
Culex tarsalis	1037	32	271	16	254	34
Culex erythrothorax	2	0.06	120	7	53	7
Culex pipiens	0	0	3	0.2	18	2
Culex salinarius	6	0.2	0	0	0	0
Anopheles freeborni	0	0	0	0	0	0
Aedes nigromaculis	0	0	0	0	2	0.3
Unidentified	0	0	0	0	0	0
TOTAL	3192		1695		758	

Wheeler Test Area

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis	1337	53				
Culiseta inornata	148	6				
Culex tarsalis	1021	40				
Culex erythrothorax	7	0.3	NONE	NONE	NONE	NONE
Culex pipiens	3	0.1				
Culex salinarius	0	0				
Anopheles freeborni	0	0				
Aedes nigromaculis	0	0				
Unidentified	26	1				
TOTAL	2542					

None = No sampling was conducted.

Appendix Table 14
(Continued)

1964 SUMMARY OF ALL MOSQUITOES COLLECTED

South Davis Sewage Treatment Plant

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis			1170	69	437	16
Culiseta inornata			173	10	1234	46
Culex tarsalis			272	16	907	34
Culex erythrothorax	NONE	NONE	58	3	96	4
Culex pipiens			8	0.5	27	1
Culex salinarius			0	0	0	0
Anopheles freeborni			0	0	0	0
Aedes nigromaculis			4	0.2	2	0.07
Unidentified			0	0	0	0
TOTAL			1685		2703	

Davis County M A D Field Office, Kaysville

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis					14	3
Culiseta inornata					23	4
Culex tarsalis					403	80
Culex erythrothorax	NONE	NONE	NONE	NONE	9	2
Culex pipiens					63	12
Culex salinarius					0	0
Anopheles freeborni					0	0
Aedes nigromaculis					0	0
Unidentified					0	0
TOTAL					512	

1964 Summary of All Mosquitoes Collected From All Study Areas

Species	Larvae Collected		Adults Collected			
			Bite Count		Light Traps	
	Number	Percent	Number	Percent	Number	Percent
Aedes dorsalis	3341	43	2275	67	715	18
Culiseta inornata	1757	22	369	11	1424	36
Culex tarsalis	2665	34	543	16	1564	39
Culex erythrothorax	12	0.2	178	5	158	4
Culex pipiens	3	0.03	11	0.3	108	3
Culex salinarius	6	0.07	0	0	0	0
Anopheles freeborni	0	0	0	0	0	0
Aedes nigromaculis	0	0	4	0.1	4	0.1
Unidentified	84	1	0	0	0	0
TOTAL	7868		3380		3973	

None = No sampling was conducted.

Appendix Table 15

1964 WATERFOWL *POPULATIONS ON FARMINGTON BAY WATERFOWL MANAGEMENT AREA

Date	BIRDS				
	Geese	Swans	Coots	Ducks	Total
January 15	0	0	0	200	200
31	20	250	0	600	870
February 15	16	275	0	1,200	1,491
29	200	200	25	1,200	1,625
March 15	350	300	200	9,000	9,850
31	275	946	4,600	24,600	30,421
April 15	400	0	2,800	11,500	14,700
30	175	0	3,900	5,900	9,975
May 15	200	0	400	3,850	4,450
31	400	0	4,300	5,400	10,100
June 15	375	0	800	2,500	3,675
30	NC	NC	NC	NC	NC
July 15	NC	NC	NC	NC	NC
31	325	0	8,000	1,200	9,525
August 15	325	0	16,000	9,000	25,325
31	375	0	16,000	26,500	42,875
September 15	500	0	33,000	27,700	61,200
30	350	0	18,200	20,000	38,550
October 15	225	0	9,000	12,100	21,325
31	250	30	2,000	9,100	11,380
November 15	450	0	1,400	11,050	12,900
30	500	0	300	2,200	3,000
December 15	300	0	400	3,000	3,700
31	125	75	100	300	600
YEAR TOTAL	6,136	2,076	121,425	188,100	317,737

* Total of counts taken on the 15th and last day of each month.

Appendix Table 16

1960-1964 NUMBER OF MUSKRATS TRAPPED ON FARMINGTON BAY WATERFOWL MANAGEMENT AREA

Year	Number of Muskrats
1960	5,926
1961	4,242
1962	5,189
1963	5,564
1964	9,080

Appendix Table 17

1964 DUCK NEST DENSITIES

Lake Front Gun, Fur and Reclamation Club

Station Number	Area in Sq. Yds.	Nests per Survey		Average No. of Nests per Acre
		#1	#2	
1	20,000	0	0	0
2	5,100	2	0	.949
6	30,000	6	4	.807
7	20,000	2	0	.242
8	40,000	16	3	1.149
9	36,000	0	0	0
10	12,000	3	2	1.008

Farmington Bay Waterfowl Management Area

Station Number	Area in Sq. Yds.	Nests per Survey		Average No. of Nests per Acre
		#1	#2	
2	3,710	0	1	.652
3	10,780	1	1	.449
5	7,960	1	0	.733
6	3,300	0	2	1.466
7	18,000	7	13	2.688
8	7,800	0	0	0
10	23,000	0	3	.316
14	4,500	2	0	1.076

Appendix Table 18

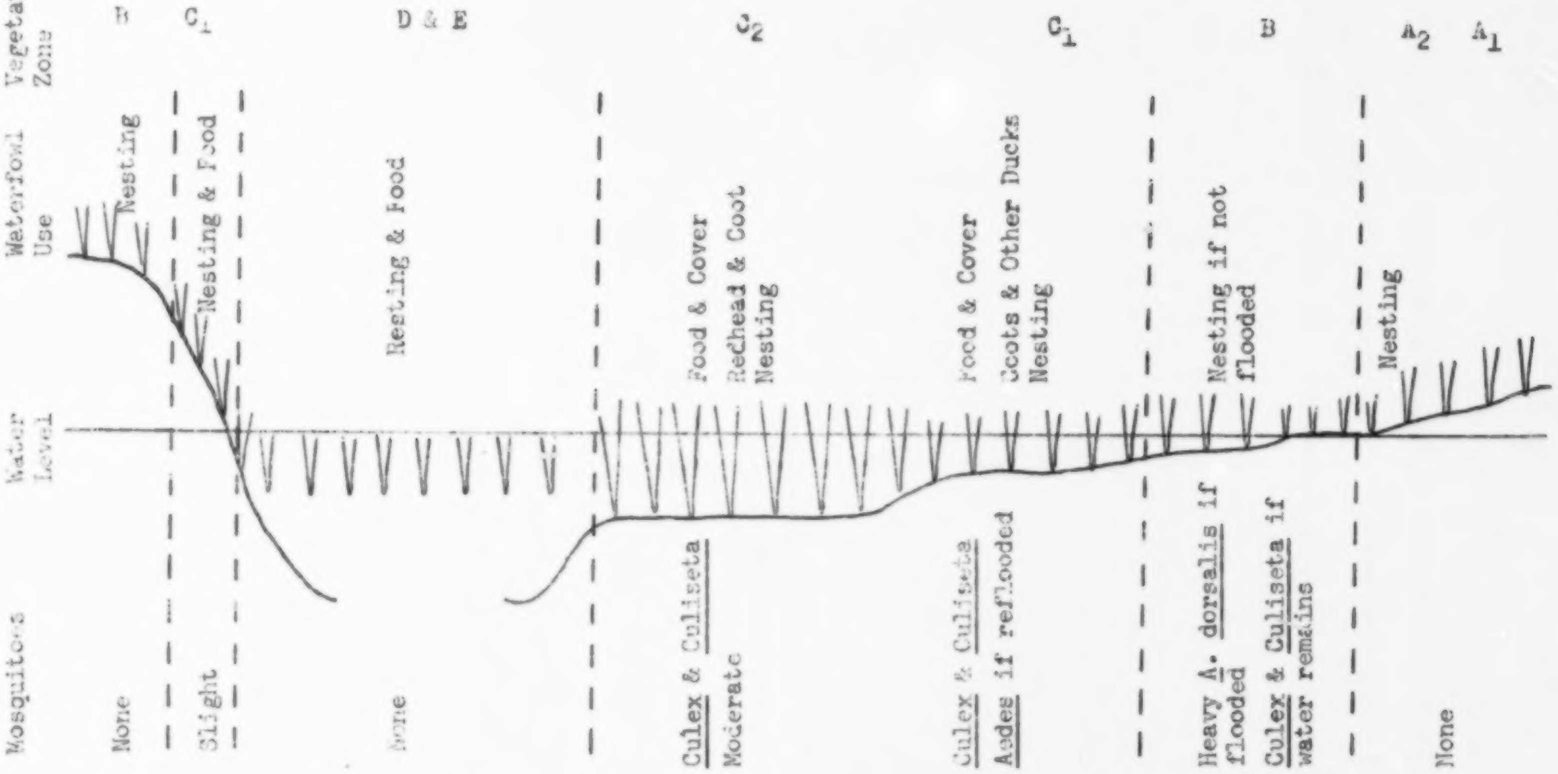
1962-1963-1964 SUMMARY OF WATERFOWL BAG CHECKS MADE ON FARMINGTON BAY WATERFOWL MANAGEMENT AREA

	1962	1963	1964
Total Hunters	2,180	2,853	3,194
Total Ducks	6,498	6,521	4,544
Ducks/Hunter	2.98	2.28	1.42
Total Geese	67	33	46

These bag checks were made on the first weekend of the hunting season.

Appendix Figure 3

WATERFOWL MARSH PROFILE



A_1 - Upland vegetation (greasewood)
A_2 - Upland vegetation (pickleweed)
B - Moist soil vegetation (salt grass)

C_1 - Shallow emergent vegetation - (alkali, Olney's, &
C_2 - Deep emergent vegetation (hardstem bulrush, (cattails)

D - Submergent vegetation (chara, widgeon grass, sago pondweed)
E - Floating aquatic vegetation (duckweed)

Appendix Table 19

WATER QUALITY DATA AT FOUR SELECTED SAMPLING STATIONS

Sampling Station and Date	5 Day BOD Mg/L	pH	MPN Coliform Organisms/100 Ml
Wheeler Machinery Company Test Area (Northwest Reservoir)			
April 22	1.5	8.40	1500
May 20	2.1	8.45	75
June 10	1.6	U*	U
July 21	1.5	7.60	210
August 18	2.6	9.50	U
September 22	1.2	9.65	239
Farmington Bay Waterfowl Management Area (Turpin Lake, first footbridge)			
April 22	5.6	8.55	23
May 20	2.1	8.70	430
June 10	1.0	9.40	U
July 21	2.3	8.90	750
August 18	3.1	9.00	U
September 22	8.1	9.00	4300
State Canal (Southend Farmington Bay Waterfowl Management Area)			
May 19	5.5	7.60	23
June 17	2.9	7.55	230,000 +
July 15	7.5	7.70	230,000 +
August 11	5.	7.75	93,000
September 24	8.6	7.90	2,300
Lake Front Gun, Fur and Reclamation Club (Marsh pond)			
May 19	3.6	7.70	9
June 17	1.	8.05	75
July 15	3.3	9.35	4
August 12	2.7	8.70	930
September 17	12.0	8.20	430

* U = Undetermined

Appendix Table 20

WATER QUALITY DATA OF EFFLUENTS AT FOUR SEWAGE TREATMENT PLANTS IN DAVIS COUNTY

Name of Plant	Date	BOD Mg/L	MPN*Coliform/ 100 Ml	Total Suspended Solids PPM
North Davis County Sewer Improvement District	1963 Sept.	35		26
	Oct.	26		17
	Nov.	19	930,000	12
	Dec.	20		13
	1964 Jan.	19		11
	Feb.	20	9,300,000	14
	Mar.	20		14
	Apr.	17	430,000	13
	May	19		13
	June	20	230,000	14
	July	19		14
	Aug.	24		15
Central Davis County Sewer Improvement District	1963 Sept.	40		28
	Oct.	41		35
	Nov.	36	750,000	23
	Dec.	35		20
	1964 Jan.	32		20
	Feb.	35	2,300,000	23
	Mar.	38		24
	Apr.	34	1,500,000	21
	May	47		35
	June	33	430,000	31
	July	-		-
	Aug.	38		35
South Davis County Sewer Improvement District (North Plant)	1963 Sept.	31		20
	Oct.	30		22
	Nov.	25	7,500,000	18
	Dec.	27		18
	1964 Jan.	29		19
	Feb.	27	430,000	15
	Mar.	27		20
	Apr.	26	930,000	22
	May	30		23
	June	29		21
	July	28		16
	Aug.	29		16
South Davis County Sewer Improvement District (South Plant)	1963 Sept.	28		18
	Oct.	31		21
	Nov.	27	2,300,000	17
	Dec.	30		18
	1964 Jan.	29		19
	Feb.	34	43,000,000	24
	Mar.	28		17
	Apr.	29	230,000	18
	May	25		17
	June	27	15,000,000	22
	July	24		17
	Aug.	21		14

* Grab samples.

Appendix Table 21

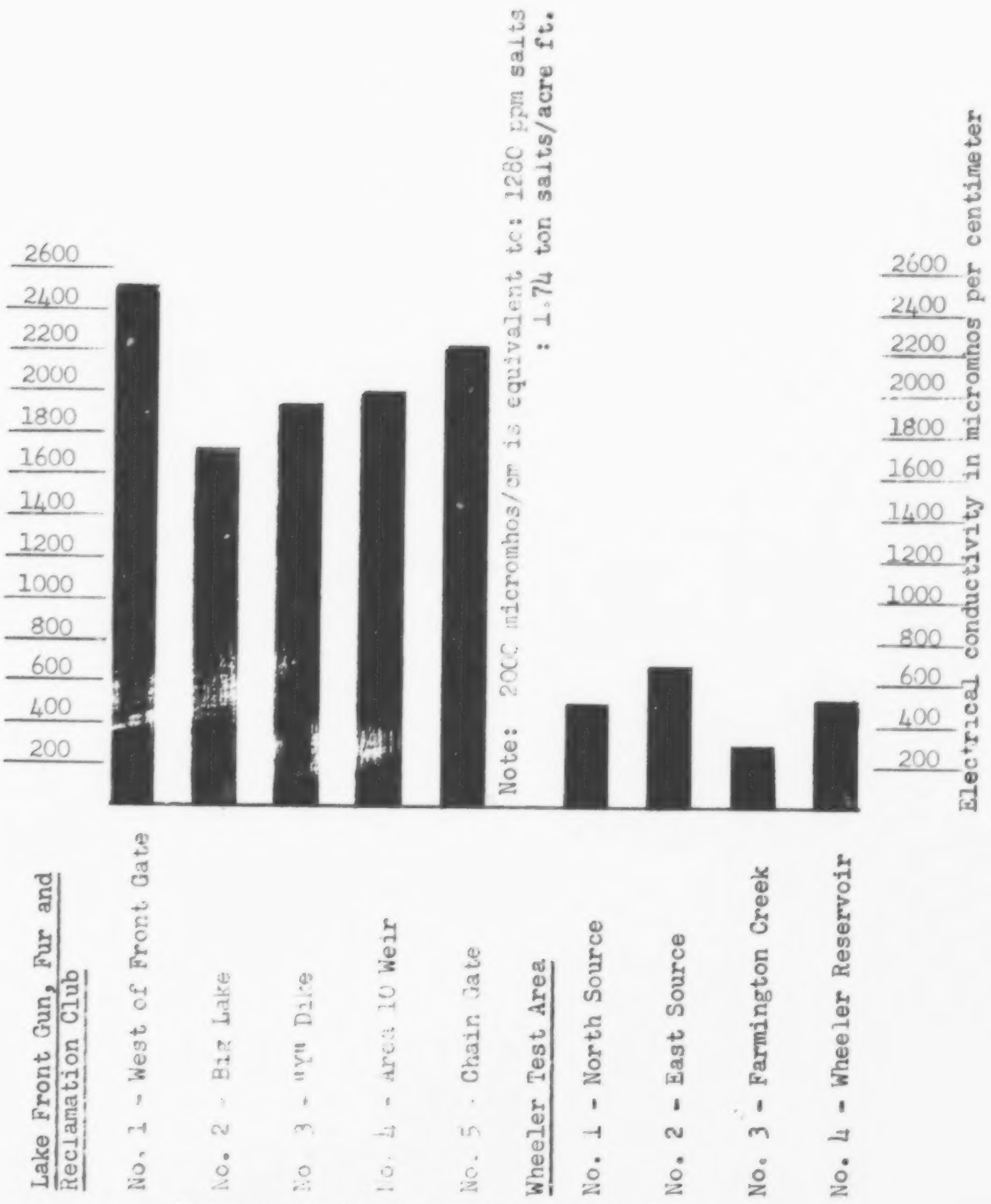
1964 ELECTRICAL CONDUCTIVITY MEASUREMENTS*

Date		Wheeler Test Area				Lake Front Gun Club				
		North Source	East Source	Farm-ington Creek	Wheeler Reserv-oir	West Front Gate	Big Lake	"Y" Dike	Area 10 Weir	Chain Gate
April	1	720	670	510	740					
	2	750	780	420	750					
	3	700	910	380	740					
	4	900	910	300	920	3400	2600	2750	2200	3300
	5	960	880	350	940	3420	2150	2650	2300	3800
May	1	830	850	330	1100					
	2	550	750	150	710	2000	1750	2300	2200	2700
	3	470	650	140	450	1750	1600	2150	2050	2200
	4	240	480	100	300	2300	1500	1750	1250	1850
June	1	330	550	170	310	1750	1200	1300	1100	1350
	2	500	630	150	480	1100	970	1600	900	1050
	3	400	590	140	440	1400	1070	1200	1220	1320
	4	460	610	170	500	1380	1100	1270	1050	1120
July	1	420	680	270	430	1550	1150	1080	1120	1220
	1					1780	1180	1120	1280	1200
	2	420	680	460	440	2150	1150	1600	1520	1450
	3	400	620	500	400	2950	1250	1200	1450	1500
	4	400	650	560	390	2150	1500	1500	2200	2370
	5	400	600	460	360	2500	1950	2250	2400	2400
Aug.	1					3700	2000	2350	2100	2350
	2	440	690	440	390	3000	1950	2000	2050	2200
	3	420	710	-	570	3600	2000	2000	2400	2250
	4	420	650	-	380	-	2000	2050	2200	2300
Sept.	1	420	650	-	400	6500	2150	2250	2600	2800
	2	420	600	-	460	-	2250	2600	3100	2750
	3	550	580	-	440	-	2600	2800	3050	3100
	4	460	600	430	460	2600	2200	2600	3600	2900
Oct.	1	480	700	480	500	2400	2240	2400	3000	2600
	2	460	650	480	440	2400	2200	2200	2800	2600
AVERAGE		515	678	333	535	2535	1748	1959	2046	2230

* Micromhos at 25° C.

Appendix Figure 4

AVERAGE ELECTRICAL CONDUCTIVITY AT SELECTED STATIONS ON THE LAKE FRONT GUN, FUR AND RECLAMATION CLUB AND THE WHEELER MACHINERY COMPANY TEST AREA



Appendix Table 22

1964 WATER ANALYSIS REPORT - LAKE FRONT GUN, FUR AND RECLAMATION CLUB

Determinations by: Soils Laboratory, Agricultural Experiment Station, Utah State University

Sampling Station Number Location and Date	Elec. Cond.	T.D.S %	Calcium epm*	Magnesium epm*	Sodium epm*	Potassium epm*	Chloride epm*	Sulfate epm*	SAR epm*	Bicarbonate epm*	Class
(1) West of Front Gate											
May	1879	.1268	4.49	5.28	10.6	.52	9.94	6.46	4.8	3.93	C3-S2
August	3590	.2590	5.22	10.55	24.7	1.16	23.35	10.64	7.3	6.46	C4-S3
September	2670	.1710	6.56	7.08	13.8	.80	11.7	9.49	5.3	5.23	C4-S2
(2) Big Lake											
May	1560	.1020	4.39	4.21	7.89	.40	7.35	5.36	3.8	3.74	C3-S1
August	1980	.1450	5.03	6.32	11.8	.60	10.37	8.33	4.9	3.93	C3-S2
September	2400	.1550	6.72	7.05	11.8	.70	9.94	9.19	4.5	4.90	C4-S2
(3) "Y" Dike											
May	2275	.1472	4.28	5.94	14.3	.65	13.28	7.24	6.2	3.53	C4-S2
August	2460	.1810	4.69	7.05	15.4	.70	14.03	10.03	6.4	2.66	C4-S2
September	2670	.1650	6.03	7.92	13.6	.81	11.4	9.43	5.1	4.23	C4-S2
(4) Area 10 Weir											
May	1938	.1284	4.07	5.37	11.2	.56	10.69	6.54	4.8	3.53	C3-S1
August	2410	.1690	3.73	7.22	15.2	.70	13.80	9.98	6.5	2.11	C4-S2
September	2460	.1580	5.78	7.59	13.0	.80	10.7	9.18	5.0	4.25	C4-S2
(5) Chain Gate											
May	2204	.1463	4.47	5.75	14.2	.62	12.76	6.96	6.3	3.93	C3-S2
August	2030	.1480	3.69	6.41	11.9	.59	10.99	8.56	5.2	2.54	C3-S1
September	2670	.1680	6.21	8.05	13.8	.80	11.5	9.37	5.1	5.00	C4-S2

*epm = equivalent per million

Appendix Table 23

1964 WATER ANALYSIS REPORT - WHEELER MACHINERY COMPANY TEST AREA

Determinations by: Soils Laboratory, Agricultural Experiment Station, Utah State University

Sampling Station Number Location and Date	Elec. Cond.	T.D.S. %	Calcium epm*	Magnesium epm*	Sodium epm*	Potassium epm*	Chloride epm*	Sulfate epm*	SAR epm*	Bicarbonate epm*	Class
(1) North Source											
May	328	.0178	1.64	.92	1.05	.10	.53	.38	1.0	2.75	C2-S1
August	415	.0312	2.24	1.15	1.16	.11	.56	.50	0.8	3.38	C2-S1
September	504	.0300	2.19	2.13	1.10	.36	.75	.64	.75	4.08	C2-S1
(2) East Source											
May	557	.0310	2.69	1.28	2.40	.13	1.12	.64	1.6	4.41	C2-S1
August	722	.0520	3.49	1.84	2.88	.20	1.30	.83	2.7	5.98	C2-S1
September	722	.0410	3.44	2.24	2.20	.37	1.19	.62	1.3	5.82	C2-S1
(3) Farmington Creek											
May	113	.0044	.60	.27	.24	.06	.20	.19	0.5	.78	C1-S1
August +											
September	512	.0300	2.84	1.53	.80	.40	.86	.71	0.6	3.89	C2-S1
(4) Wheeler Reservoir											
May	437	.0222	1.68	1.14	1.94	.12	.94	.57	1.4	3.18	C2-S1
August	378	.0256	.68	1.27	2.10	.14	.87	.39	1.2	2.66	C2-S1
September	478	.0270	.75	1.53	2.20	.36	1.24	.49	2.0	3.61	C2-S1

* epm = equivalent per million
+ = dry

Appendix Table 24

WATER ANALYSES OF FARMINGTON BAY WATERFOWL MANAGEMENT AREA

Prepared by U. S. Department of the Interior,
Geological Survey, Salt Lake City, Utah

Salt Lake City Laboratory Number	26891 F
Date of collection	12-6-63
Silica (Si)2)	15
Calcium (Ca)	109
Magnesium (Mg)	95
Sodium (Na)) Potassium (K))	470
Bicarbonate (HCO3)	294
Carbonate (CO3)	0
Sulfate (SO4)	448
Chloride (Cl)	690
Fluoride (F)	0.8
Nitrate (NO3)	3.7
Boron (B)	.48
Dissolved solids:	
Calculated	1,980
Residue on evaporation at 180° C	2,030
Hardness as CaCO3	664
Non-carbonate hardness as CaC)3	423
Percent sodium	61
Sodium-Adsorption Ratio	7.9
Specific Conductance micromhos at 25° C	3,230
pH	7.5
Temperature	34
Mean daily discharge in cfs	92
Analysis	"C"

Results in parts per million except as indicated.

Appendix Table 25

CHEMICAL QUALITY DATA OF JORDAN RIVER

LOCATION: At highway bridge on 21st South Street, Salt Lake City, Utah.
DRAINAGE AREA: 3,420 sq. mi. approx. including 255 sq. mi. in closed basin in Cedar Valley.
RECORDS AVAILABLE: Chemical analyses: May 1948-Aug. 1948; June, 1957-Jan. 1959 (misc. samples).

Prepared by U. S. Department of the Interior, Geological Survey, Salt Lake City, Utah.

Data	Date of Collection								
	Nov. 5 1963	Dec.13 1963	Jan.15 1964	Feb.20 1964	Mar.20 1964	Apr.18 1964	July 14 1964	Aug.17 1964	Aug.28 1964
*Mean daily discharge (cfs)	198	181	169	175	187	205	201	341	252
Silica (SiO2)	18	20	22	21	23	17	18	20	19
Iron (Fe)	-	-	-	-	-	-	-	-	-
Calcium (Ca)	152	143	150	139	143	120	127	124	141
Magnesium (Mg)	75	76	80	66	77	56	65	64	72
Sodium (Na)	209	204	199	197	209	179	197	216	220
Potassium (K)									
Bicarbonate (HCO3)	184	218	248	294	304	262	285	296	302
Carbonate (CO3)	0	0	0	0	0	0	0	0	0
Sulfate (SO4)	515	458	477	381	413	320	361	380	395
Chloride (Cl)	320	305	305	285	310	260	278	285	326
Fluoride (F)	-	-	-	-	-	-	-	-	-
Nitrate (NO3)	6.1	8.6	6.6	11	11	7.6	11	6.4	10
Boron (B)	-	-	-	-	-	-	-	-	-
Dissolved solids: Parts per million	1390	1350	1360	1240	1340	1090	1200	1240	1330
Hardness as CaCO3: Calcium, Magnesium	690	670	702	620	672	530	582	575	648
Non-carbonate	539	470	499	379	423	315	348	332	400
Sodium adsorption ratio	3.5	3.4	3.3	3.4	3.5	3.4	3.6	3.9	3.8
Specific conductance: micromhos at 25° C	2100	2010	2030	1860	2050	1630	1870	1890	2100
pH	6.8	8.5	7.5	7.5	7.6	7.5	7.5	7.8	8.2
Temperature °F	53	42	36	45	50	49	62.5		59.5

* Combined discharge of Surplus Canal and Jordan River below diversion.

Appendix Table 26

CHEMICAL QUALITY OF JORDAN RIVER BELOW CUDAHY LANE

LOCATION: At highway bridge on Cudahy Lane, about 6.3 mi. northwest of Salt Lake City, Utah.
DRAINAGE AREA: 3,490 sq. mi. approx. 255 sq. mi. in closed basin in Cedar Valley.

Prepared by U. S. Department of the Interior, Geological Survey, Salt Lake City, Utah.

Data	Date of Collection									
	Nov.19 1963	Dec.13 1963	Jan.15 1964	Feb.20 1964	Mar.20 1964	Apr.17 1964	May 6 1964	July 23 1964	Aug.17 1964	Sept.14 1964
Mean daily discharge (cfs)	39	97	103	117	104	119	173	98	90	120
Silica (SiO2)	21	21	20	21	21	17	12	18	19	17
Iron (Fe)	-	-	-	-	-	-	0	-	-	-
Calcium (Ca)	140	147	141	135	136	112	89	109	112	119
Magnesium (Mg)	71	70	78	69	69	50	34	61	61	69
Sodium (Na)	203	215	196	182	202	153	75	186	192	194
Potassium (K)							6.2			
Bicarbonate (HCO3)	234	229	226	286	301	252	242	268	287	276
Carbonate (CO)	0	0	0	0	0	0	0	0	0	0
Sulfate (SO4)	445	455	491	362	372	293	146	332	349	355
Chloride (Cl)	295	320	280	280	300	210	120	250	242	282
Fluoride (F)	-	-	-	-	-	-	0.3	-	-	-
Nitrate (NO3)	13	13	8.5	10	8	11	3.8	12	7.8	10
Boron (B)	-	-	-	-	-	-	0.15	-	-	-
Dissolved solids:										
Parts per million	1300	1350	1330	1200	1260	998	649	1100	1120	1180
Tons per acre-foot	1.77	1.84	1.81	1.63	1.71	1.36	.88	1.50		1.60
Tons per day	372	354	370	379	265	321	231	294	281	382
Hardness as CaCO3:										
Calcium, Magnesium	640	656	672	618	624	484	362	522	530	580
Non-carbonate	448	468	487	383	377	277	164	302	295	354
Sodium adsorption ratio	3.5	3.6	3.3	3.2	3.5	3.0	2.9	3.6	3.6	3.5
Specific conductance (micromhos at 25°C)	2010	2050	2010	1900	1960	1490	1020	1680	1730	1850
pH	7.0	7.2	7.8	7.6	7.4	7.4	7.5	7.4	7.8	8.1
Temperature °F	42	38	36	40	48	52	48	77		68

Appendix Table 27

SPECIFIC CONDUCTANCE DATA ON JORDAN RIVER AT CUDAHY LANE

Prepared by U. S. Department of the Interior, Geological Survey, Salt Lake City, Utah

Date	Time	Gage Height	*Discharge	Temp °F	Kx 10^6 (micromhos)	Lab. No.
10-14-63	1245	4.63	87	58	1700	26697
11-5-63	0745	2.72	98	50	2030	26780
11-27-63	1555	2.21	71		2100	26932
3-11-64	1300	2.48	128	43	2050	27161
3-17-64	0900	2.59	134	48	1900	27106
2-24-64	1420	2.58	120	46	1920	27160
4-16-64	0905	2.25	117	56	1740	27282
5-21-64	0705	4.00	285	51	464	27511
5-28-64	0820	3.32	216	49	444	27604
6-30-64	1545	2.56	156	67	773	27766
7-27-64	0800	1.94	107	69	1660	28088
7-30-64	0900		82	74	1700	27962
8-26-64	1250	1.95	86	69	1640	28181
8-7-64	0845	2.06	96	72	1640	28180
9-9-64	1530	2.87	123		1710	28182
9-24-64	0910	2.89	132	58	1870	28287

* Mean daily discharge in cfs.

Appendix Table 28

WATER ANALYSES OF SURPLUS CANAL AT COHEN FLUME NEAR SALT LAKE CITY, UTAH

Prepared by U. S. Department of the Interior, Geological Survey, Salt Lake City, Utah

Salt Lake City Laboratory Number	27673	28445
Date of collection	6-22-64	9-23-64
Silica (SiO_2)	10	5.1
Calcium (Ca)	63	92
Magnesium (Mg)	25	75
Sodium (Na) Potassium (K)	80	208
Bicarbonate (HCO_3)	154	200
Carbonate (CO_3)	0	0
Sulfate (SO_4)	152	385
Chloride (Cl)	105	302
Nitrate (NO_3)	3.8	.6
Dissolved solids:		
Calculated	515	1170
Residue on evaporation at 180° C	527	1180
Hardness as $CaCO_3$	260	540
Non-carbonate hardness as $CaCO_3$	134	376
Percent sodium	40	46
Sodium Adsorption Ratio	2.2	3.9
Specific Conductance micromhos at 25°C	854	1830
pH	7.6	7.6
Temperature	52	60
Mean daily discharge in cfs	331	137
Analysis	"C"	"C"
Appearance	muddy	

Results in parts per million except as indicated.

Appendix Table 29

SPECIFIC CONDUCTANCE DATA ON SURPLUS CANAL AT COHEN FLUME

Prepared by U. S. Department of the Interior, Geological Survey, Salt Lake City, Utah

Date	Time	Gage Height	*Discharge	Temp °F	$K \times 10^6$ (micromhos)	Lab. No.
10-14-63		1.69	160	59	2030	26698
11-19-63	1345		181	45	2130	26751
12-13-63	1250	3.53	98	38	2090	26822
1-15-64	1245	1.10	69	33	2140	26933
2-20-64	0945	1.93	47	36	1990	27058
3-5-64	1415	1.80	44	40	2030	27165
3-18-64	1100	2.48	88	--	1970	27166
3-25-64	1355	1.90	53	45	2030	27277
4-17-64	1430	2.40	82	56	1990	27310
5-19-64	1130	4.96	335	55	893	27510
5-26-64	1600	5.27	380	55	603	27605
6-25-64	1410	4.24	214	63	887	27765
7-29-64	1210	3.07	98	74	1940	28086
7-16-64	1555	3.41	105	76	1870	28084
8-24-64	1600	1.76	51	74	1920	28179
10-15-64	1320	4.00	131	57	2050	28290

* Mean daily discharge in cfs.

Appendix Table 30

DEFINITIONS OF CLASS "C" AND CLASS "D" WATERS

Class "C" Waters shall be so protected against pollution as to be suitable at all times for domestic water supplies which are treated before use by coagulation, sedimentation, filtration, and disinfection. Class "C" waters shall be suitable without treatment for irrigation, stock watering, fish and wildlife propagation, recreation (except swimming), as a source for industrial supplies, and for other uses as may be determined by the the Utah Water Pollution Board.

No person shall discharge into Class "C" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by "Public Health Service Drinking Water Standards, 1962," or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agricultural Handbook No. 60," issued February, 1954, or

(3) which result in a monthly arithmetical average "most probable number (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of the samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 5 milligrams per liter (mg/l); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 10 mg/l in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids or sludge deposits in said waters which are readily visible, or which result in appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 6.5 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters injurious to fish life and waterfowl, or unsafe or unsuitable as sources of water supply for domestic use, food processing or industrial use, or unsuitable for agricultural purposes, stock watering, or recreation.

Class "D" Waters shall be so protected against pollution as to be suitable at all times for limited irrigation, not including irrigation of lawns, recreational areas, pastures used for dairy cattle, root crops, or any low growing crops produced for human consumption. Such waters shall be suitable also as a source for industrial supplies and for other uses as may be determined by the Utah Water Pollution Board.

(Continued)

Appendix Table 30
(Continued)

No person shall discharge into Class "D" waters any wastes

(1) which result in chemical characteristics of said waters exceeding the limits prescribed by "Public Health Service Drinking Water Standards, 1962" or

(2) which result in chemical characteristics of said waters exceeding the recommendations for irrigation water quality as outlined in Chapter 5 of the U. S. Department of Agriculture "Agricultural Handbook No. 60," issued February, 1954, or

(3) which result in a monthly arithmetical average "most probable number" (MPN) of coliform organisms in said waters exceeding 5,000 per 100 milliliters; or in an MPN exceeding this number in more than 20% of samples collected during any month; or in an MPN exceeding 20,000 per 100 milliliters in more than 5% of such samples, or

(4) which result in a monthly arithmetical average biochemical oxygen demand (BOD) in said waters exceeding 25 milligrams per liter (mg/l); or in a BOD exceeding this amount in more than 20% of the samples collected in any month; or in a BOD exceeding 50 mg/l in more than 5% of such samples, or

(5) which result in any slicks, floating solids, suspended solids or sludge deposits in said waters which are readily visible, or which result in an appreciable change in color of said waters, or

(6) which result in a pH of said waters lower than 6.5 or greater than 9.0, or

(7) which contain any toxic wastes, phenols, or other deleterious substances in such concentrations or at such temperatures as will render said waters unsuitable for the uses designated for Class "D" waters above.

These definitions are from Utah State Department of Health Waste Disposal Regulations.

Appendix Table 31

DEFINITIONS OF CLASSES OF WATER BASED ON SODIUM HAZARD AND SALINITY

Waters are divided into four classes with respect to conductivity, the dividing points between classes being 250, 750, and 2,250 micromhos per centimeter.

Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very high-salinity water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt-tolerant crops should be selected.

Since the sodium absorption ratio (SAR) is included in the classification of waters, the basis for the "S" classification is included.

Low sodium waters (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodiums. However, sodium-sensitive crops may accumulate injurious concentrations of sodium.

Medium sodium water (S2) will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity, especially under low leaching conditions, unless gypsum is present in the soil. This water may be used on coarse textured or organic soils with good permeability.

High sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management, good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very high sodium water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.

Appendix Table 32

DAILY DISCHARGE IN SECOND FEET OF COMBINED JORDAN RIVER AND SURPLUS CANAL AT SALT LAKE CITY, UTAH FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division, File No. 10-1710.00

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	220	211	199	173	189	174	201	289	466	413	254	290
2	224	204	200	175	194	181	204	434	475	363	266	293
3	222	203	199	171	191	169	198	410	633	324	244	268
4	223	201	197	167	186	170	195	302	625	264	235	286
5	271	198	198	171	178	174	204	278	561	269	248	274
6	279	202	196	169	184	178	206	273	745	253	301	285
7	286	229	196	173	187	174	196	274	1,160	245	313	314
8	292	187	191	164	189	174	195	279	1,070	234	309	321
9	302	174	191	157	185	178	192	268	718	226	288	343
10	268	170	190	165	189	180	217	258	540	221	274	323
11	265	166	187	173	188	179	213	266	463	224	259	324
12	294	151	183	171	182	185	209	288	391	217	249	311
13	279	149	181	168	182	189	194	300	392	218	253	291
14	256	143	180	169	178	186	179	420	450	201	258	291
15	241	173	181	169	176	202	175	485	474	248	262	308
16	220	188	184	166	182	230	181	494	558	243	341	330
17	203	172	180	165	182	234	199	523	601	227	341	315
18	202	200	177	165	174	227	205	571	717	204	323	280
19	221	210	177	164	174	222	215	571	725	195	317	298
20	232	220	172	171	175	187	271	547	643	205	314	312
21	210	218	175	196	175	204	210	662	675	203	313	313
22	182	223	176	196	174	213	209	744	760	207	299	294
23	183	217	169	191	175	214	195	691	660	223	310	302
24	200	216	168	188	173	200	234	744	582	256	273	297
25	180	203	175	189	169	194	216	696	565	282	241	282
26	190	191	173	191	168	196	240	677	547	287	229	258
27	200	186	176	185	168	209	264	782	571	291	236	252
28	200	203	176	183	170	212	234	720	596	222	303	255
29	180	199	177	183	171	215	231	768	566	227	296	252
30	200	197	177	187		212	269	629	496	235	275	253
31	221		173	183		203		537		239	289	
TOTAL	7,146	5,804	5,674	5,438	5,208	6,065	6,351	15,180	18,425	7,666	8,713	8,815

Appendix Table 33

DAILY DISCHARGE IN SECOND FEET OF THE JORDAN RIVER AT SALT LAKE CITY, UTAH FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division, File No. 10-1710.00

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	76	89	93	89	110	126	140	113	0	114	81	128
2	73	86	94	91	112	129	98	87	68	104	83	125
3	74	85	96	92	112	124	139	99	115	98	78	72
4	75	83	97	92	111	125	139	119	97	88	76	45
5	85	83	98	94	111	128	141	44	100	89	78	33
6	86	80	96	94	114	130	143	88	92	87	86	81
7	89	47	96	96	117	129	142	80	88	89	94	135
8	92	51	94	94	119	129	141	57	23	87	94	135
9	94	45	94	92	120	132	141	38	13	88	91	139
10	89	44	93	95	124	132	150	39	41	95	87	134
11	90	43	92	98	125	131	148	40	78	103	83	131
12	97	34	91	99	125	133	139	43	96	101	66	125
13	75	40	89	98	125	135	121	24	116	100	77	119
14	77	37	88	99	124	134	97	0	119	96	78	116
15	66	34	89	99	124	139	97	0	123	104	79	119
16	76	20	89	99	125	146	99	0	133	102	92	123
17	78	30	88	98	126	147	103	0	83	98	92	122
18	77	32	88	98	124	145	102	0	67	94	89	39
19	80	68	90	97	124	138	105	0	81	92	87	91
20	81	103	88	99	125	84	108	0	110	92	84	119
21	79	86	88	104	125	141	102	0	104	90	83	124
22	76	81	89	104	124	143	101	0	74	89	80	98
23	61	97	87	107	125	144	97	0	51	91	80	123
24	72	96	86	106	125	139	108	0	45	97	72	122
25	68	71	88	107	123	138	100	0	66	99	65	120
26	68	55	89	107	123	139	108	0	119	97	84	116
27	72	60	89	106	123	142	111	0	119	97	98	116
28	75	89	89	106	124	142	105	0	121	81	114	116
29	68	88	90	106	125	143	105	0	119	80	117	116
30	78	91	90	108		142	113	0	119	79	117	117
31	93		89	106		140		0		80	124	
TOTAL	2,440	1,948	2,817	3,080	3,514	4,169	3,543	7,918	2,580	2,901	2,709	3,299

Appendix Table 34

DAILY DISCHARGE IN SECOND FEET OF THE JORDAN RIVER BELOW CUDAHY LANE NEAR SALT LAKE CITY, UTAH FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	a 79	96	93	90	108	117	134	174	160	157	98	110
2	a 76	93	93	88	108	133	123	240	126	146	90	112
3	a 77	90	96	90	104	123	120	198	192	140	88	132
4	a 78	90	96	88	103	119	136	192	196	132	85	142
5	a 88	98	96	88	106	122	144	214	188	130	85	145
6	a 89	99	97	89	108	131	144	173	202	126	94	110
7	a 92	121	96	91	108	128	140	139	266	120	96	110
8	a 95	107	97	92	107	123	140	174	239	118	95	116
9	a 97	93	98	93	107	125	139	145	188	110	98	123
10	a 92	90	100	95	109	132	164	146	206	117	92	119
11	a 100	90	98	97	111	128	159	158	174	118	89	120
12	a 115	91	98	98	107	125	156	168	174	117	88	119
13	a 95	88	97	99	108	134	140	194	186	116	81	119
14	a 87	88	91	102	109	131	116	225	183	114	87	120
15	a 77	92	88	103	109	132	112	243	186	116	82	128
16	a 81	123	88	103	112	134	117	260	190	116	82	129
17	a 81	100	88	103	113	134	119	268	230	108	90	129
18	a 80	90	88	103	113	132	120	274	206	106	83	119
19	a 83	39	88	102	117	134	124	289	170	103	90	87
20	a 84	80	87	104	117	104	162	288	178	104	87	119
21	a 82	94	91	113	117	126	131	285	192	100	88	131
22	a 91	84	91	109	120	141	128	294	220	99	88	125
23	76	90	89	107	120	147	119	281	174	98	84	126
24	80	93	89	106	120	138	158	274	160	95	90	132
25	77	90	89	104	123	135	133	262	144	97	81	130
26	87	75	89	106	124	134	161	234	172	103	86	128
27	81	71	90	104	122	139	168	232	170	107	102	129
28	84	82	91	104	117	135	142	216	172	85	108	131
29	94	88	93	104	117	136	145	268	167	85	114	131
30	95	93	91	108		136	157	209	156	82	109	131
31	106		90	109		135		174		89	110	
TOTAL	2,699	2,718	2,866	3,092	3,264	4,043	4,151	6,891	5,567	3,454	2,840	3,702

a = No gage-height record, discharge estimated.

Appendix Table 35

DAILY DISCHARGE IN SECOND FEET OF THE SURPLUS CANAL AT SALT LAKE CITY, UTAH FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division, File No. 10-1705.00

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	144	122	106	84	79	48	61	176	466	299	173	162
2	151	118	106	84	82	52	106	347	407	259	183	168
3	148	118	103	79	79	45	59	311	518	226	166	196
4	148	118	100	75	75	45	56	183	528	176	159	241
5	186	115	100	77	67	46	63	234	461	180	170	241
6	193	122	100	75	70	48	63	264	653	166	215	204
7	197	182	100	77	70	45	54	194	1,070	156	219	179
8	200	136	97	70	70	45	54	222	1,050	147	215	186
9	208	129	97	65	65	46	51	230	705	138	197	204
10	179	126	97	70	65	48	67	219	499	126	187	189
11	175	123	95	75	63	48	65	226	385	121	176	193
12	197	117	92	72	57	52	70	245	295	116	183	186
13	204	109	92	70	57	54	73	276	276	118	176	172
14	179	106	92	70	54	52	82	420	331	105	180	175
15	175	139	92	70	52	63	78	485	351	144	183	189
16	144	168	95	67	57	84	82	494	425	141	249	207
17	125	142	92	67	56	87	96	523	518	129	249	193
18	125	168	89	67	50	82	103	571	650	110	234	241
19	141	142	87	67	50	84	110	571	644	103	230	207
20	151	117	84	72	50	103	163	547	533	113	230	193
21	131	132	87	92	50	63	108	662	571	113	230	189
22	106	142	87	92	50	70	108	744	686	118	219	196
23	122	120	82	84	50	70	98	691	609	132	230	179
24	128	120	82	82	48	61	126	744	537	159	201	175
25	112	132	87	82	46	56	116	696	499	183	176	162
26	122	136	84	84	45	57	132	677	428	190	145	142
27	128	126	87	79	45	67	153	782	452	194	138	136
28	125	114	87	77	46	70	129	720	475	141	189	139
29	112	111	87	77	46	72	126	768	447	147	179	136
30	122	106	87	79		70	156	629	377	156	158	136
31	128		84	77		63		537		159	165	
TOTAL	4,706	3,856	2,857	2,358	1,694	1,896	2,808	14,388	15,846	4,765	6,004	5,516

Appendix Table 36

DAILY DISCHARGE IN SECOND FEET OF THE SURPLUS CANAL AT COHEN FLUME NEAR SALT LAKE CITY, UTAH FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	a 100	176	105	80	77	49	59	147	241	66	98	43
2	a 110	127	105	82	84	58	100	239	193	88	118	62
3	a 110	115	103	79	83	50	76	280	287	121	99	64
4	a 110	118	102	76	78	46	52	184	298	55	100	86
5	a 150	120	102	77	67	44	58	187	235	47	112	50
6	a 150	111	102	77	67	49	67	201	300	80	153	90
7	a 160	158	102	76	70	45	53	124	a 600	49	162	93
8	a 160	146	102	73	65	43	50	118	a 600	33	164	88
9	a 170	145	102	67	65	44	46	135	a 400	20	148	104
10	a 140	140	103	69	66	47	58	126	316	38	119	113
11	a 140	131	100	74	67	44	76	129	217	55	51	130
12	a 160	125	98	74	59	44	79	139	139	56	42	128
13	a 160	117	98	71	56	52	63	173	117	67	38	119
14	a 160	112	98	68	53	48	44	244	145	67	46	122
15	174	103	96	69	49	54	51	337	170	82	46	122
16	168	143	97	68	53	77	61	307	200	105	74	144
17	149	143	95	64	56	80	82	305	247	96	113	179
18	136	160	94	64	49	88	92	329	294	82	83	241
19	141	181	93	66	47	81	99	335	277	72	78	206
20	151	136	92	68	47	127	143	337	218	190	83	174
21	139	125	93	97	49	63	119	318	258	197	55	173
22	118	141	94	97	47	60	103	375	331	150	67	190
23	109	128	90	87	49	69	81	359	276	151	80	137
24	131	127	90	82	49	57	104	375	256	159	51	118
25	109	132	93	78	48	53	105	369	214	174	16	130
26	118	132	91	81	43	51	111	380	149	175	26	116
27	131	128	93	82	42	63	145	402	110	136	35	96
28	127	119	94	79	43	68	118	393	148	85	70	97
29	114	115	98	76	43	75	109	353	200	98	65	90
30	115	109	84	79		70	130	345	113	97	34	87
31	184		79	74		64		275		90	59	
TOTAL	4,294	3,963	2,988	2,354	1,671	1,863	2,534	8,320	7,549	2,981	2,485	3,592

a = No gage-height record, discharge estimated.

Appendix Table 37

DAILY DISCHARGE IN SECOND FEET OF GOGGIN DRAIN NEAR MAGNA, UTAH
FOR THE YEAR ENDING SEPTEMBER 30, 1964

U. S. Department of the Interior, Geological Survey, Water Resources Division

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	2.4	11	1.2	0.8	0.6	0.9	2.6	22	260	188	11	69
2	3.5	2.2	1.2	0.8	0.7	1.0	2.1	31	220	90	8.9	58
3	5.7	1.9	1.1	0.7	0.8	1.1	3.2	33	202	47	8.2	57
4	6.0	1.7	1.1	0.6	0.8	1.0	1.5	26	272	43	8.9	67
5	7.9	1.9	1.0	0.6	0.8	0.8	2.1	56	275	33	9.3	113
6	9.7	1.7	0.9	0.6	0.8	1.0	1.7	132	303	7.3	12	39
7	7.3	2.1	0.9	0.6	0.6	1.0	2.1	128	374	5.4	14	32
8	4.8	1.9	0.8	0.5	0.6	1.1	1.5	117	398	5.1	11	29
9	1.7	1.7	1.2	0.4	0.5	1.2	1.5	126	349	11	12	29
10	6.2	1.9	0.9	0.2	0.6	1.1	1.7	119	331	8.9	37	28
11	7.6	2.6	0.6	0.3	0.7	1.1	1.5	117	262	8.9	92	12
12	6.8	1.4	0.6	0.6	0.9	1.2	2.1	119	229	10	92	15
13	4.8	1.3	0.6	1.1	1.1	1.2	1.9	134	193	9.3	90	14
14	4.0	1.3	0.8	0.2	1.0	1.3	1.9	193	179	7.3	92	17
15	2.4	1.3	1.0	0	1.3	1.2	1.5	238	188	8.5	98	10
16	2.2	1.7	1.0	0	0.8	1.7	1.4	236	223	8.5	96	7.3
17	2.1	2.2	1.2	0	0.7	6.2	5.8	232	305	7.0	142	11
18	1.4	1.7	0.8	0	0.5	7.0	7.0	232	398	6.5	234	17
19	1.4	1.7	0.9	0	0.6	4.0	7.6	236	396	5.4	153	7.0
20	1.4	1.4	0.9	0.2	0.6	3.5	9.3	240	351	6.2	157	7.0
21	1.4	1.3	0.6	1.5	0.6	2.9	8.5	240	296	5.4	149	8.9
22	1.3	1.4	0.9	1.0	0.7	2.9	12	270	341	4.5	136	10
23	1.9	1.3	0.6	0.7	0.8	3.2	18	288	334	2.6	123	6.8
24	3.5	1.3	0.6	1.1	0.7	3.8	20	282	316	3.8	104	5.4
25	3.5	1.3	0.6	1.3	0.8	5.1	20	282	324	2.9	67	8.5
26	3.5	1.3	0.6	1.0	0.7	5.7	25	291	294	1.9	67	7.9
27	2.6	1.3	0.7	0.8	0.7	4.5	28	316	255	6.2	47	9.3
28	1.0	1.2	0.7	0.9	0.6	4.3	24	326	255	7.0	40	17
29	0.8	1.2	0.7	1.0	0.7	4.3	22	314	243	4.5	77	10
30	1.3	1.2	0.9	0.6		4.0	21	306	238	7.9	75	14
31	5.0		0.8	0.6		3.5		282		10	58	
TOTAL	115.1	57.4	26.4	18.7	21.3	82.8	258.5	5,964	8,604	573	2,321.3	736.1

Appendix Table 38

DAILY DISCHARGE IN SECOND FEET OF NORTH POINT CANAL BELOW GOSS FLUME AT SALT LAKE CITY, UTAH, FOR THE YEAR ENDING SEPTEMBER 30, 1964

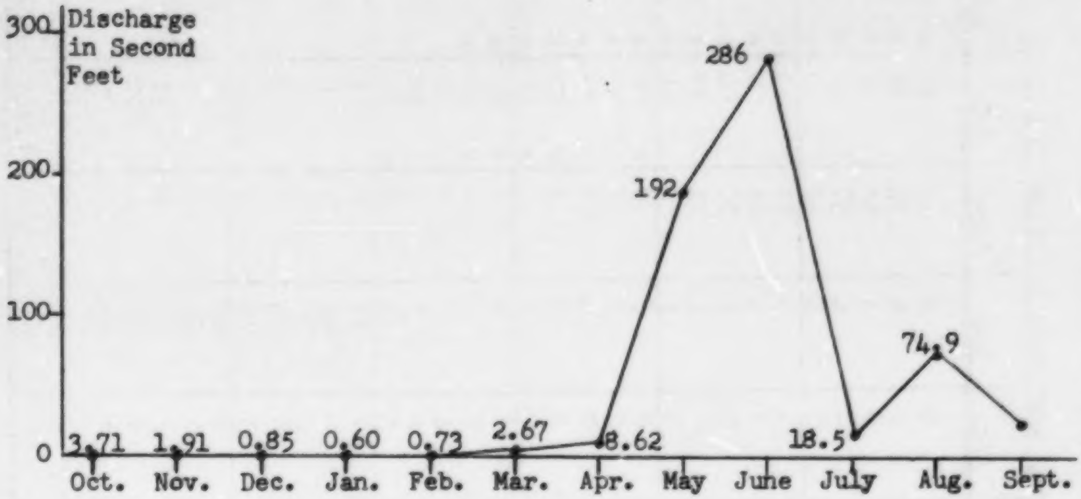
U. S. Department of the Interior, Geological Survey, Water Resources Division

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	a 40						0	6	45	60	e 60	60
2	a 40						0	6	34	66	e 55	60
3	e 40						0	5	46	67	e 50	58
4	a 40						0	4	57	66	e 45	58
5	a 40						0	4	65	70	e 45	58
6	a 40						0	5	69	69	e 45	54
7	e 40						0	4	66	68	e 40	46
8	e 40						0	4	58	66	e 40	46
9	a 40						0	4	21	69	e 40	50
10	a 40						0	5	0	71	e 40	50
11	a 40						0	5	0	e 66	e 40	51
12	a 40						0	4	0	e 50	e 35	52
13	a 40						a 9	2	0	e 50	e 30	51
14	a 20						a 9	0	0	e 50	e 30	52
15	a 10						a 9	0	0	e 40	e 30	52
16	a 10						9	0	0	e 30	e 30	51
17	a 10						a 7	0	0	e 30	e 15	19
18	e 10						4	0	0	e 30	0	0
19	a 10						4	0	0	e 30	0	0
20	a 10						5	0	0	e 10	0	0
21	a 10						5	32	0	0	0	0
22	a 10						4	68	0	0	0	0
23	a 10						4	70	0	0	0	0
24	e 10						5	70	0	0	0	24
25	e 10						5	70	0	0	31	45
26	e 10						5	68	0	0	57	45
27	e 10						6	66	0	0	58	43
28	e 10						5	65	1	38	59	40
29	e 10						6	63	2	73	59	40
30	e 10						6	66	16	75	59	38
31	e 5							67		75	61	
TOTAL	705	0	0	0	0	0	107	763	480	1,319	1,054	1,143

a = No gage-height record, discharge estimated.
e = Stage-discharge relation doubtful, discharge estimated.

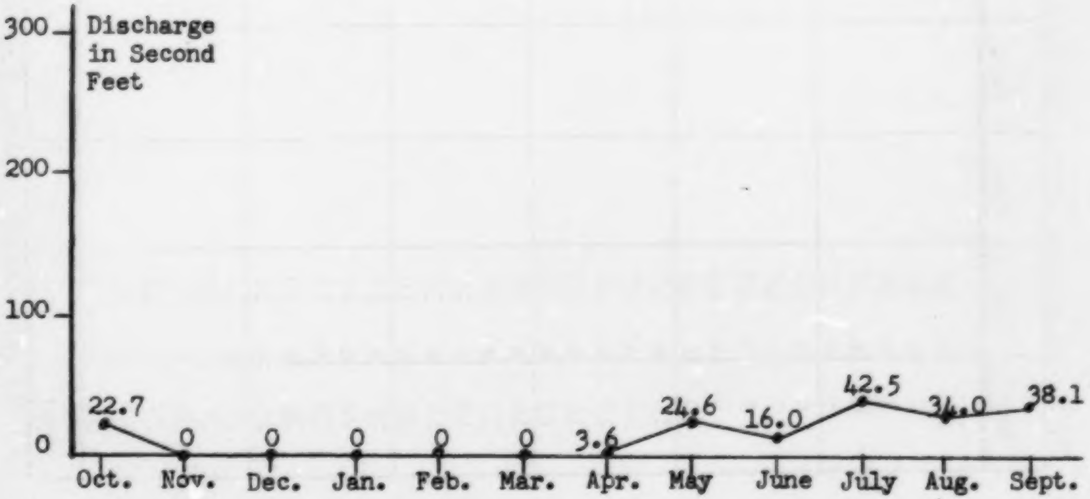
Appendix Figure 5

1964 DAILY MEAN DISCHARGE IN SECOND FEET
OF GOGGIN DRAIN, NEAR MAGNA, UTAH



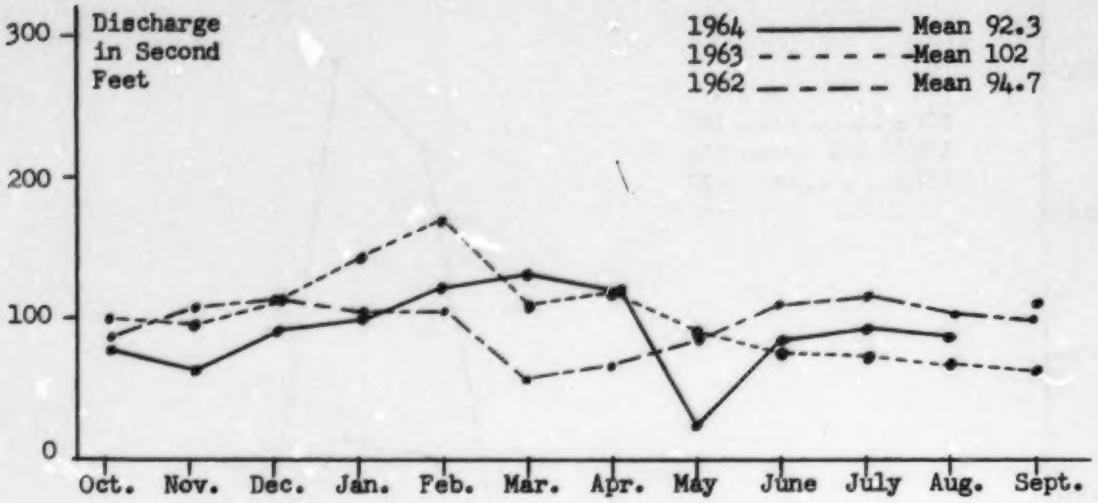
Appendix Figure 6

1964 DAILY MEAN DISCHARGE IN SECOND FEET OF NORTH POINT CANAL
BELOW GOSS FLUME AT SALT LAKE CITY, UTAH



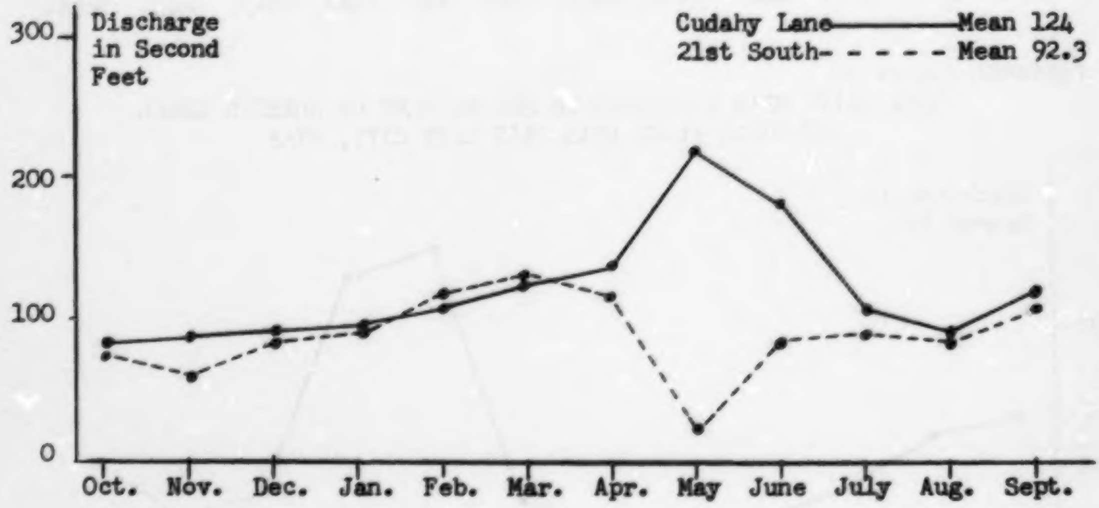
Appendix Figure 7

1962-1963-1964 DAILY MEAN DISCHARGE IN SECOND FEET OF JORDAN RIVER AT 2100 SOUTH STREET, SALT LAKE CITY, UTAH



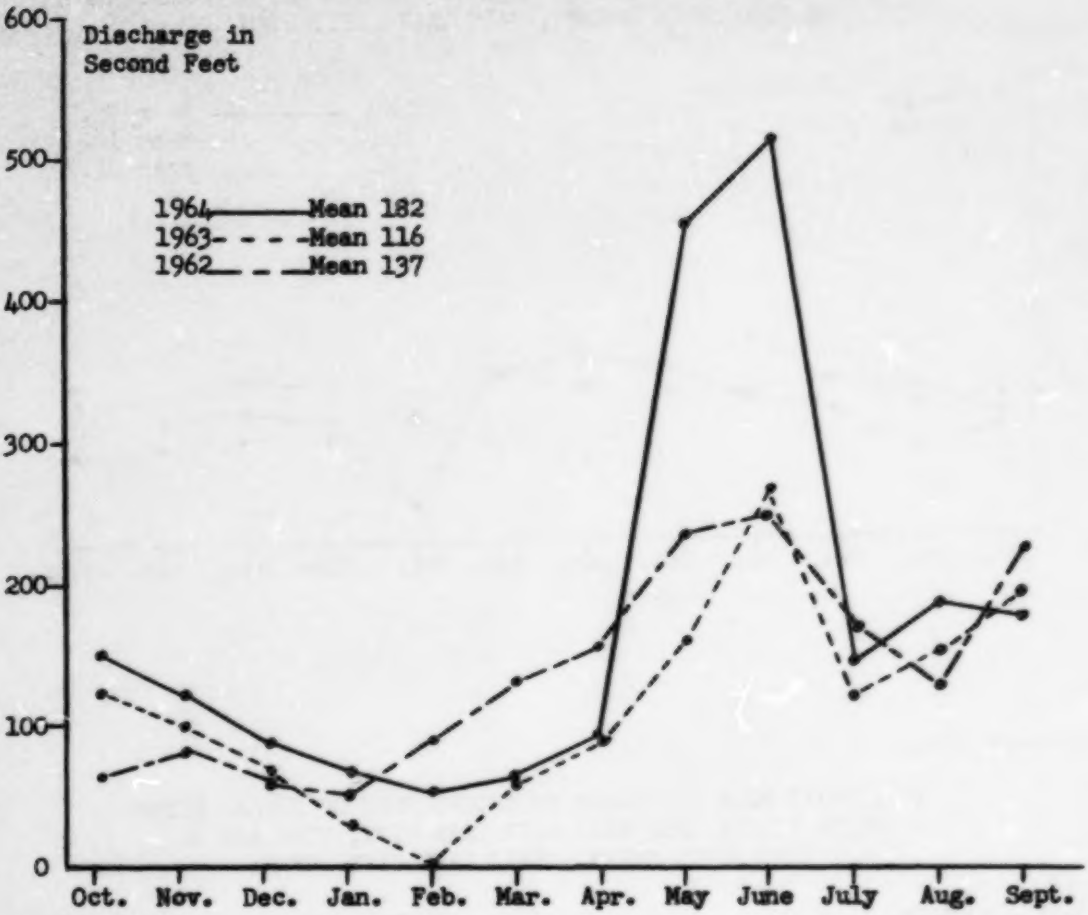
Appendix Figure 8

1964 DAILY MEAN DISCHARGE IN SECOND FEET OF JORDAN RIVER BELOW CUDAHY LANE NEAR SALT LAKE CITY, UTAH AND AT 2100 SOUTH STREET, SALT LAKE CITY, UTAH



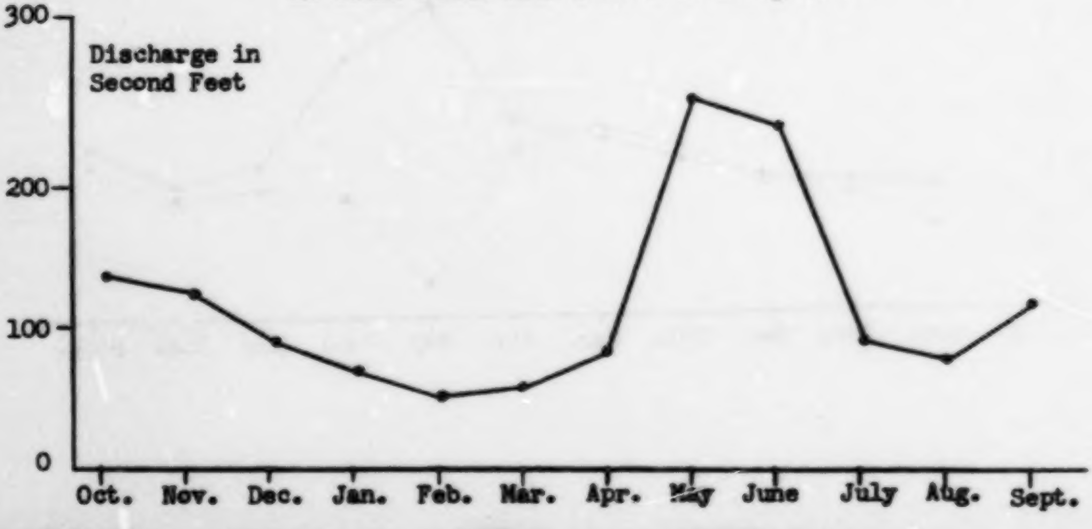
Appendix Figure 9

1962-1963-1964 DAILY MEAN DISCHARGE IN SECOND FEET OF SURPLUS CANAL AT SALT LAKE CITY, UTAH SHOWN AS DAILY MEAN PER MONTH



Appendix Figure 10

1964 DAILY MEAN DISCHARGE IN SECOND FEET OF SURPLUS CANAL AT COHEN FLUME NEAR SALT LAKE CITY, UTAH



Appendix Table 39

1963-1964 SEWAGE EFFLUENTS FROM SALT LAKE CITY AND DAVIS COUNTY

Date	Salt Lake City Pumping Station Untreated	Salt Lake City Gravity Flow (Approx. 74% of Pumping Station) Untreated	North Davis Sewer Improvement District Treated	Central Davis Sewer Improvement District Treated	South Davis Sewer Improvement District, North Plant Treated	South Davis Sewer Improvement District, South Plant Treated
Sept. 1963	19.1	13.6	7.60	1.63	2.83	1.18
Oct. 1963	17.0	12.6	6.30	1.00	2.58	1.15
Nov. 1963	17.0	12.6	5.90	0.95	2.43	0.93
Dec. 1963	17.0	12.6	5.60	1.06	2.19	U
Jan. 1964	16.8	12.4	5.00	1.10	2.32	1.02
Feb. 1964	17.6	13.0	5.40	1.14	2.21	1.08
Mar. 1964	20.2	14.9	6.30	1.15	2.58	1.13
Apr. 1964	22.1	16.3	7.00	1.64	2.97	1.06
May 1964	25.2	18.6	9.60	3.33	U	1.00
June 1964	23.3	17.4	8.40	2.14	3.77	1.04
July 1964	22.5	16.6	8.30	U	3.77	0.67
Aug. 1964	19.9	14.7	8.20	1.73	3.77	0.53

The figures show the average daily flow by month in million gallons per day.

U = Undetermined.

Appendix Table 40

EVAPORATION DATA FROM FARMINGTON BAY WEATHER STATION
MONTH: MAY, 1964

Time of Observation: 8:00 a. m.

Day	Temperature °F			Water Temp. ° F		Precipi- tation in inches	Daily wind movement MPH	Daily evaporation in inches
	Max.	Min.	Dew Point	Max.	Min.			
1	63	42	45			.04	37	.08
2	61	32	31			1.24	09	.19
3	42	31	24			.12	59	.05
4	47	31	30				40	.13
5	59	31	-			.90	113	.06
6	44	33	37			.44	37	.14
7	51	36	37			.08	47	.11
8	54	41	40			.27	53	.08
9	54	35	38	60	40	.02	44	.09
10	61	39	42	77	46		24	.18
11	66	43	36	79	46		74	.30
12	59	35	35	74	44		34	.20
13	71	50	46	80	47		39	.25
14	80	47	37	76	51		89	.30
15	77	46	50	85	53		23	.18
16	79	47	37	87	55		27	.33
17	84	49	41	81	49		76	.41
18	71	41	46	82	52		29	.30
19	75	47	51	84	55		29	.27
20	87	57	46	91	58		32	.25
21	84	53	45	81	54		88	.41
22	80	51	50	89	56		33	.25
23	76	48	43	84	56		26	.25
24	72	47	42	86	55		22	.27
25	78	59	52	71	55		77	.26
26	78	56	52	75	56		37	.20
27	78	48	54	79	53	.20	43	.18
28	-	-	-	-	-		-	-
29	-	-	45	-	-	.56	139*	.29*
30	-	-	-	-	-		-	-
31	-	-	-	-	-		-	-

* Accumulation since last reading.

Appendix Table 40
(Continued)

EVAPORATION DATA FROM FARMINGTON BAY WEATHER STATION
MONTH: JUNE, 1964

Time of Observation: 8:00 a. m.

Day	Temperature °F			Water Temp. °F		Precipitation in inches	Daily wind movement MPH	Daily evaporation in inches
	Max.	Min.	Dew Point	Max.	Min.			
1	-	-	48	-	-	.09	-	.59*
2	78#	55#	51	90#	59#		101*	.30
3	81	51	52	87	57	.01	51	.22
4	75	49	48	85	57		13	.15
5	81	57	56	86	61		21	.25
6	77	54	55	82	60	.12	24	.24
7	79	48	46	79	53	.78	67	.29
8	56	45	47	61	49	.85	23	.07
9	62	48	48	71	53	.09	27	.09
10	70	45	46	72	52		24	.18
11	69	49	48	70	53		41	.19
12	67	47	49	81	54		17	.21
13	73	49	51	85	57	.08	36	.25
14	70	47	49	84	56		22	.15
15	75	57	52	85	62	.04	18	.32
16	78	54	55	77	60		21	.14
17	68	50	52	72	54	.24	40	.10
18	58	43	45	56	48	.37	27	.07
19	69	44	49	73	50	.26	47	.00
20	69	48	49	74	53		16	.35
21	65	44	49	80	50	.15	31	.13
22	64	45	47	60	48	.19	26	.14
23	67	45	51	81	51	.17	06	.17
24	76	49	57	89	58		07	.36
25	84	52	58	93	61		08	.29
26	92	58	58	95	63		13	.26
27	90	69	52	81	63		56	.33
28	83	62	64	81	63		64	.32
29	84	61	53	83	63		30	.23
30	91	61	53	90	62		32	.26

* Accumulation since last reading.
# Highest or lowest since last reading.

Appendix Table 40
(Continued)

EVAPORATION DATA FROM FARMINGTON BAY WEATHER STATION
MONTH: JULY, 1964

Time of Observation: 8:00 a. m.

Day	Temperature °F			Water Temp. °F		Precipitation in inches	Daily wind movement MPH	Daily evaporation in inches
	Max.	Min.	Dew Point	Max.	Min.			
1	90	51	54	89	60		28	.37
2	92	57	46	91	61		01	.37
3	93	52	54	89	59		-	.39
4	91	62	51	93	61		-	.40
5	91	-	51	83	57		-	.42
6	-	50#	51	92	60		-	.26
7	89#	52	55	89	62		-	.32
8	94	55	51	95	64		-	.47
9	95	56	62	95	68		-	.34
10	97	57	56	78	59		-	.28
11	89	61	53	95	62		-	.26
12	93	65	51	96	67		-	.30
13	97	65	61	99	68		-	.32
14	94	68	58	94	66		-	.39
15	91	60	56	84	64		-	.37
16	95	56	52	88	62		-	.44
17	93	56	51	93	63		-	.36
18	98	62	50	96	65		-	.40
19	99	54	49	91	61		-	.41
20	98	57	51	95	62		-	.39
21	98	57	54	89	66		-	.30
22	99	58	58	95	65		-	.34
23	98	63	63	96	67		-	.45
24	-	-	-	-	-		-	-
25	-	-	39	-	-		-	.75*
26	92#	52#	45	90#	61#		-	.32
27	94	57	50	91	64		-	.35
28	-	-	-	-	-		-	-
29	-	-	60	-	-		-	-
30	-	-	-	-	-		-	-
31	-	-	-	-	-		-	-

* Accumulation since last reading.

# Highest or lowest since last reading.

Appendix Table 40
(Continued)

EVAPORATION DATA FROM FARMINGTON BAY WEATHER STATION
MONTH: AUGUST, 1964

Time of Observation: 8:00 a. m.

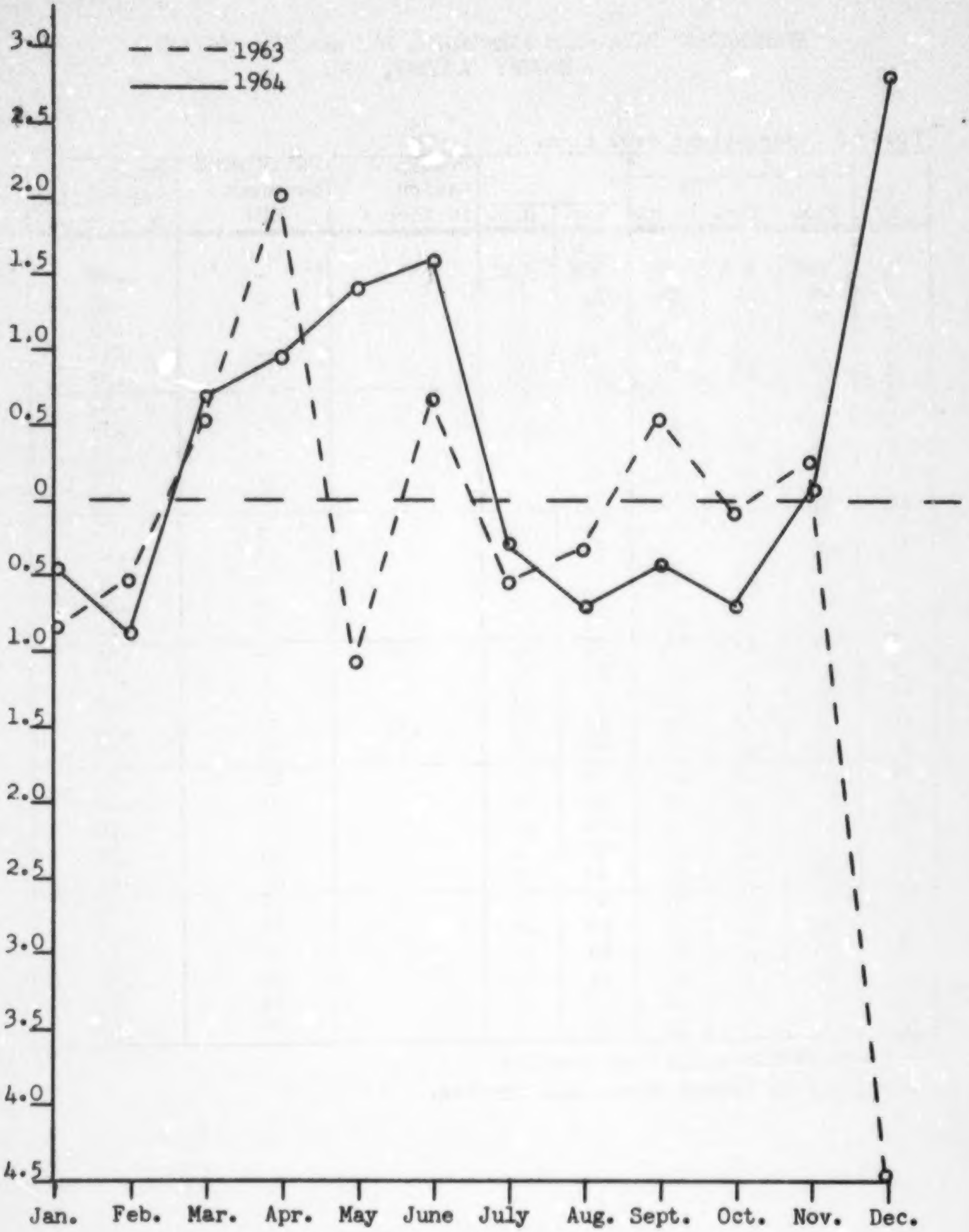
Day	Max.	Min.	Dew Point	Max.	Min.	Precipitation in inches	Daily wind movement MPH	Daily evaporation in inches
1	99#	62#	59	97#	63#		-	1.28*
2	93	58	48	84	61		-	.42
3	91	60	55	91	65		-	.26
4	95	63	55	95	65		-	.38
5	97	69	59	95	66		-	.38
6	91	59	58	83	62		-	.26
7	91	60	59	89	63		-	.23
8	96	62	60	96	67		-	.39
9	95	65	60	93	67		-	.39
10	97	64	53	98	68		-	.36
11	94	57	57	92	64		-	.29
12	94	59	54	93	67		-	.32
13	85	58	57	93	63		-	.36
14	89	58	52	94	62		-	.38
15	90	58	53	91	62		-	.40
16	93	60	53	91	61	.10	-	.38
17	83	54	55	89	62		-	.27
18	90	55	51	92	61		-	.22
19	94	60	45	85	60	.22	92	.54
20	72	41	40	81	50		35	.30
21	69	40	44	79	51		22	.24
22	68	50	40	62	51		01	.00
23	75	46	50	73	43		19	.10
24	84	46	61	87	44		18	.31
25	92	54	55	90	59		43	.41
26	91	56	51	95	60		19	.30
27	90	41	35	89	48		62	.39
28	70	46	40	82	51		22	.15
29	76	36	35	64	42		62	.30
30	68	37	29	73	48		18	.15
31	84	60	42	82	54		77	.38

* Accumulation since last reading.

# Highest or lowest since last reading.

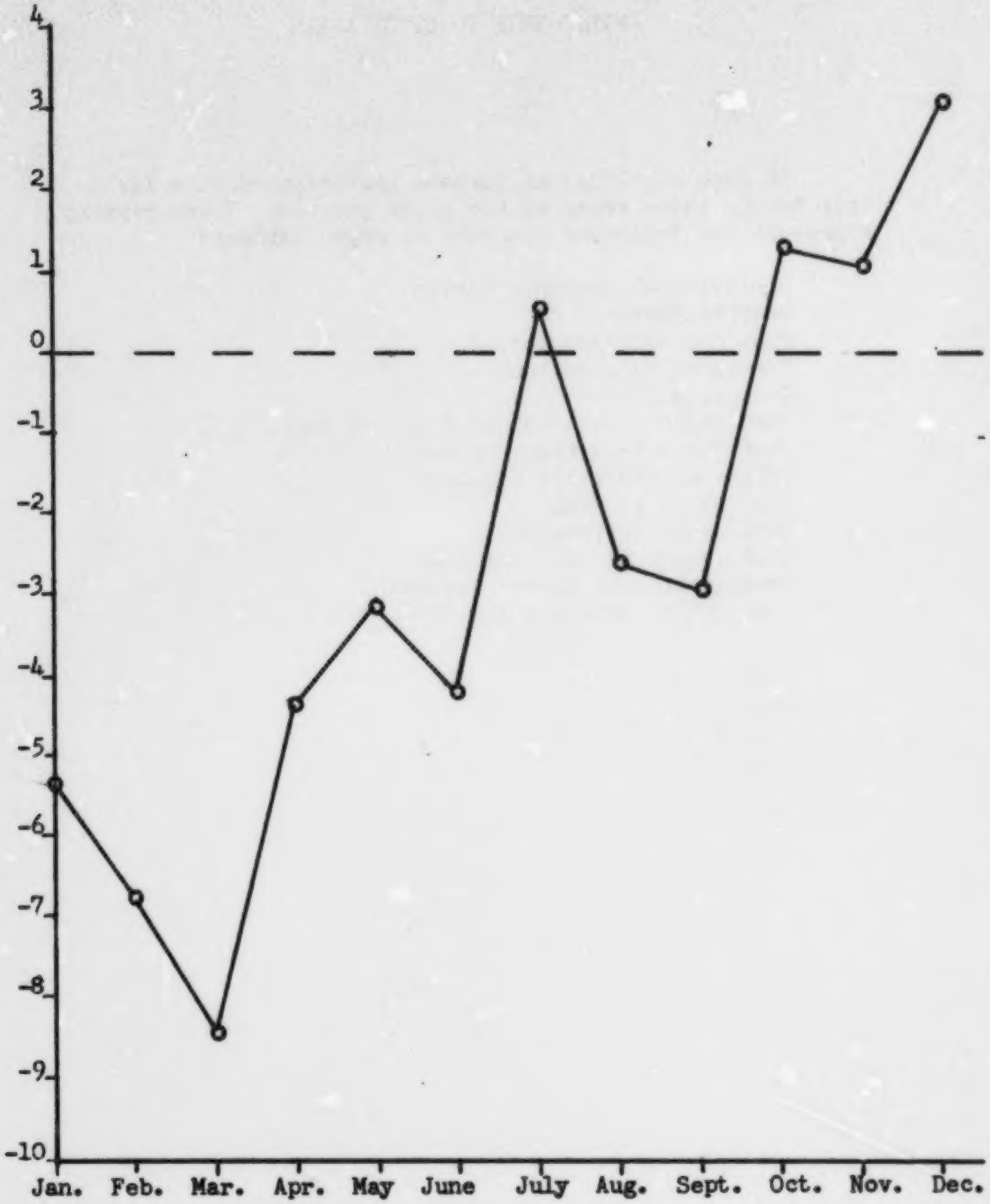
Appendix Figure 11

1963 AND 1964 PRECIPITATION IN INCHES DEVIATION FROM NORMAL



Appendix Figure 12

1964 TEMPERATURE DEVIATION FROM NORMAL IN F°



Appendix Figure 13

FIELD TRIP TO STUDY AREAS

On June 12, 1964, 44 persons participated in a field trip to the three areas of the study project. These persons represent the following agencies or organizations:

Agricultural Research Service
Weather Bureau
Fish and Wildlife Service
Bureau of Reclamation
Geological Survey
Utah State Department of Fish and Game
Utah State Department of Health
Office of the State Engineer
University of Utah
Utah State University
Utah County Health Department
Several private duck clubs and
  mosquito abatement districts

Appendix Figure 14

PHASES OF THE 1964 MULTI-PURPOSE WATER MANAGEMENT PROGRAM

1. 2500 No. Redwood Road,
   Salt Lake City

Personnel of the Public Health Service provide technical assistance in the encephalitis surveillance program.

2. Farmington Bay Waterfowl
   Management Area

Weather Bureau personnel and personnel of the Utah State Department of Fish and Game collaborate in obtaining meteorological data.

3. Lake Front Gun Club

Records of the fluctuations of the water levels in the marsh areas are essential in planning the multipurpose water management program.

4. Goggin Drain

Personnel of the Geological Survey assist by providing water quality and quantity data on waters flowing into the research areas.

5. Lake Front Gun Club

Mosquito abatement personnel assist in the construction of a small dike to improve water management in a heavy mosquito breeding area.

6. Lake Front Gun Club

Public Health Service personnel and project personnel observe large dike under construction.

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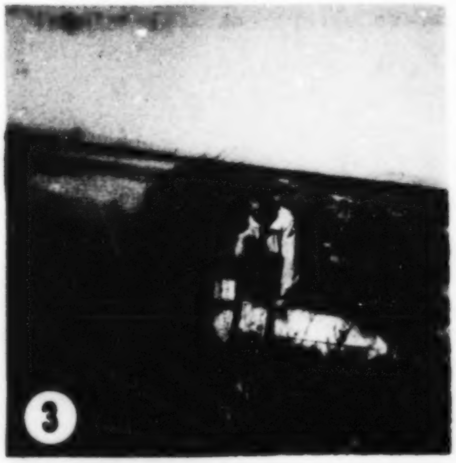
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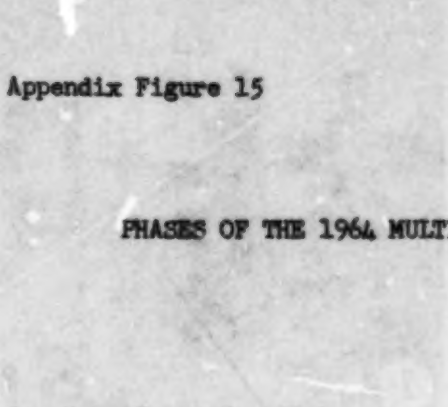
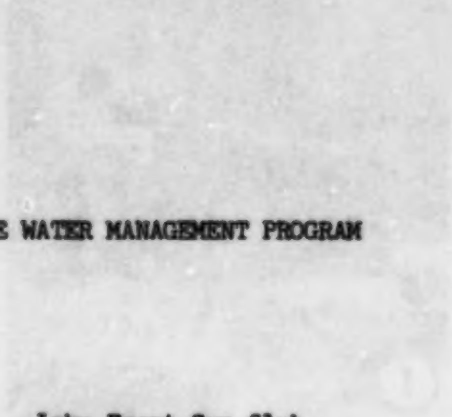
Appendix Figure 15

PHASES OF THE 1964 MULTI-PURPOSE WATER MANAGEMENT PROGRAM



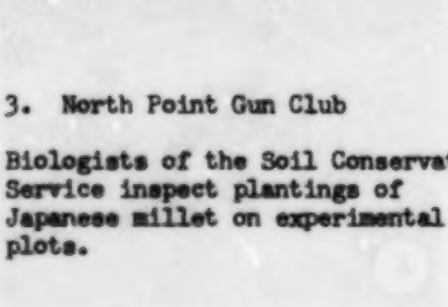
1. Lake Front Gun Club

Personnel of the Soil Conservation Service and project personnel cooperate in establishing an agricultural site for experimental planting of food plants for waterfowl.



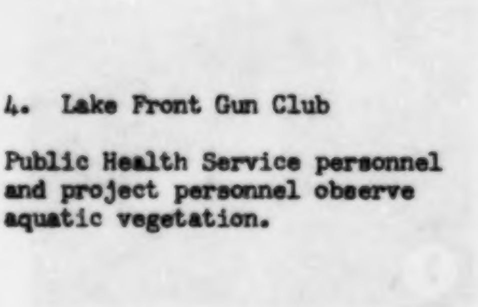
2. Lake Front Gun Club

Personnel of the Public Health Service and project personnel discuss experimental plantings.



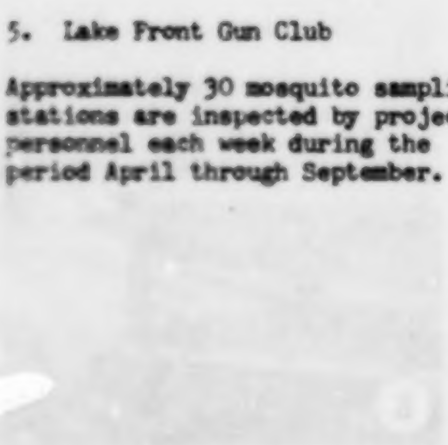
3. North Point Gun Club

Biologists of the Soil Conservation Service inspect plantings of Japanese millet on experimental plots.



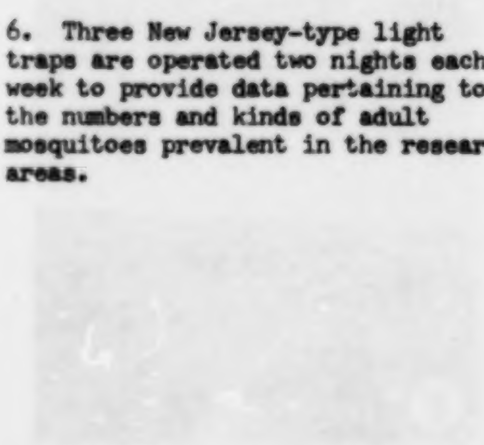
4. Lake Front Gun Club

Public Health Service personnel and project personnel observe aquatic vegetation.

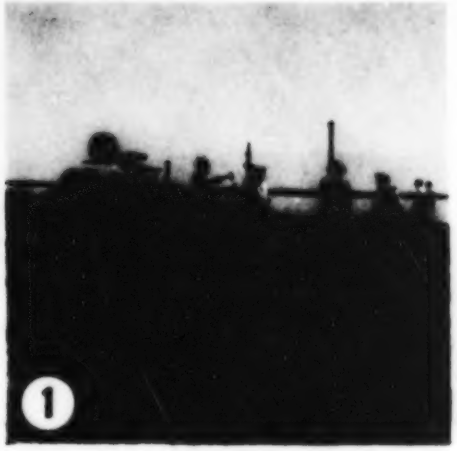


5. Lake Front Gun Club

Approximately 30 mosquito sampling stations are inspected by project personnel each week during the period April through September.



6. Three New Jersey-type light traps are operated two nights each week to provide data pertaining to the numbers and kinds of adult mosquitoes prevalent in the research areas.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ARTICLES PREPARED BY COLLABORATING AGENCIES FOR INCLUSION IN ANNUAL REPORT #3

Agricultural Research Service Report

By Lyman S. Willardson
Agricultural Engineer

The Agricultural Research Service of the U. S. Department of Agriculture is one of the collaborating agencies on this project. As a collaborating agency, the ARS has no direct responsibility for the conduct of the project. The ARS does, however, have an obligation to assist in the orderly advancement of the research effort.

This project, which is working on the development of techniques for multi-purpose management of reusable water before it enters the Great Salt Lake, encompasses problems which are of interest to the Soil and Water Conservation Research Division of the Agricultural Research Service. Previous studies made by the Division have shown that efficient use of water in irrigated agriculture not only produces agricultural conservation benefits but also results in diminished mosquito production. Further work on the project will show that efficient use of water is beneficial in many aspects besides reducing mosquito production.

As a collaborating agency, the Agricultural Research Service can both assist and gain in the cooperative effort. During research development conferences, the points of view of the researchers and other collaborators are available. In the annual report and work review presentation, the research results can be examined and questions can be asked which strengthen the research program and which provide information to the collaborating agency. Opportunities are available to the collaborating agencies to develop cooperative projects within the framework of both responsibilities which will result in more complete use of time and talent. Also the cooperation established allows for direct consultation on plans and problems during the conducting of research. Such consultation increases the efficiency of the program.

As the project progresses, the Agricultural Research Service will have an opportunity to participate more fully in soil and water management phases that develop. Water is reusable until it evaporates or is degraded in quality to a detrimental level. Techniques for multi-purpose use of water are needed to extend the useful life of Utah's limited water supply.

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Soil Conservation Service Report

By John Metcalf
State Soil Conservationist

During 1964, Soil Conservation Service technicians assisted three Soil Conservation District cooperators in applying soil and water conservation practices on their lands in the project area.

The Wheeler Machinery Company, cooperating with the Davis Soil Conservation District, and the Lake Front Gun Club, cooperating with the Salt Lake Soil Conservation District, both have Soil Conservation District conservation plans. The North Point Fur and Reclamation Company, cooperating with the Salt Lake Soil Conservation District, is in the process of developing a conservation plan. All three organizations are applying conservation practices that fit into their proposed land and water management objectives.

The Wheeler Machinery Company has made excellent progress in land leveling, pasture planting, irrigation system development and in the construction of a headquarters and corral area. It is expected that the first of the dikes for waterfowl resting and nesting ponds will be constructed this fall starting in the area south of the headquarters and corral.

In the area occupied by the North Point and Lake Front Clubs, the major problem is that of strongly saline-alkali soils. This problem is compounded by generally poor quality irrigation water. Both organizations in 1964 made trial plantings of millet to see if this waterfowl food plant could be successfully grown on these soils.

In order to be able to irrigate the millet plantings, the trial fields were leveled and bordered. Irrigation water was pumped from the lake. Reasonably good success was obtained on the North Point Club seeding. On the Lake Front seeding, poor establishment and growth resulted from the lowering of the lake water which cut off the irrigation.

In addition to the millet plantings, the two clubs did other application of conservation measures.

The Lake Front Gun Club has:

1. Repaired and rebuilt one mile of water-control dike, using a bulldozer.

2. Repaired and rebuilt one and one-half miles of dike using a dragline.

3. Repaired flumes.

4. Built a bridge.

5. Constructed 1/4 mile of new dike.

6. Installed two new weirs and two new flumes.

7. Planted alkali bulrush sprigs which are doing well.

The dikes which were built or rebuilt have a sixteen foot top width so that they can be driven on for maintenance purposes.

Plans have been made to seed the newly constructed dikes with tall wheatgrass, sweet clover and millet. The irrigated millet plantings will be tried again next year, with some modification in techniques. Wild millet seed will be collected locally for planting.

The North Point Gun Club has:

1. Had a soil survey made on their property by Soil Conservation Service soil scientists.

2. Started to develop a district conservation plan.

3. Arranged for the construction of 1-1/4 miles of water-control dike.

4. Planned tall wheatgrass, sweet clover, millet and alkali bulrush plantings along dikes.

In 1964 the Soil Conservation Service, in addition to technical services rendered to district cooperators, obtained ion analyses on water samples taken at nine locations in the project area. The completion of the 1964 series of samples will give six sets of water quality data which will be useful in predicting irrigation water quality. These data may also prove useful in mosquito propagation evaluation.

In coming years, the Soil Conservation Service expects to continue to assist the afore-mentioned district cooperators with their application of soil and water conservation practices, and in their planting activities.

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Evaporation Station - Farmington Bay

By Eugene L. Peck
Hydrologist in Charge
Water Supply Forecast Unit
Department of Commerce, Weather Bureau

One of the most complex and least understood phenomenon of the hydrologic cycle is evaporation or evapotranspiration. The network of evaporation stations in northern Utah is fairly good. However, there are about 30,000 acres of marsh lands bordering the southeastern portion of Great Salt Lake for which evaporation basic data has been sorely lacking.

The Weather Bureau was pleased to cooperate with the University of Utah, the Utah Fish and Game Department and the Salt Lake City

Mosquito Abatement District in installing and operating an evaporation station at the Bird Refuge office at Farmington Bay, Utah (Farmington Bay Waterfowl Management Area).

A full "Class A" evaporation station was installed which includes the following equipment:

Instrument shelter
Maximum thermometer
Minimum thermometer
Standard raingage
Monel evaporation pan
Fixed point evaporation gage
Totalizing anemometer
Water temperature assembly (non-floating)

Most of the equipment was installed during July, 1963, and the full station has been in operation since September 8, 1963. During warmer months of the year (approximately six months), daily weather measurements are made of all factors including pan evaporation. During the colder months when freezing conditions prevent accurate measurement of pan evaporation, daily measurements of maximum and minimum temperatures, precipitation, snowfall, total wind movement and humidity are taken.

The records from the Farmington Bay station will provide valuable measurements on the evaporation from the marsh land area of the Great Salt Lake Basin. Many studies have been made using daily pan evaporation for indices to actual and potential evapotranspiration. Weather Bureau Research Paper No. 38, "Evaporation from Pans and Lakes" gives an empirical relation for computing lake evaporation from the measurements taken by a full "Class A" evaporation station. Computed lake evaporation represents the amount of water which would be evaporated from a freewater surface or from a marsh area with an unlimited water supply. This computed lake evaporation is of direct value in arriving at water loss or potential evaporation for the marsh areas. Weather Bureau Research Paper No. 38 also has a procedure for computing daily lake evaporation when observed pan measurements are not available. For this purpose, mean daily temperature, daily wind movement and average dew point are required. All of these values may be computed from the measurements which are being made during the winter months. Thus, estimates of lake evaporation will be available for the entire year. Computer programs are available for computing lake evaporation by the two methods and all daily records from the Farmington Bay station are to be placed on punch cards.

A dense network of evaporation stations has been operated under a joint project by the Forest Service and the Weather Bureau for the past three years on the Davis County Experimental Area of the Forest Service, directly east of Farmington Bay. The radiational and other measurements collected on a continuous basis at the Farmington Warehouse of the Forest Service and at the eleven other stations in the network will greatly increase the overall value of the records being collected at Farmington Bay.

Summaries of the records collected this past summer (May-August) at Farmington Bay are shown in Appendix Table 40.

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Multipurpose Benefits of the Cooperative Research Project on Multi-purpose Management Techniques for Reusable Water in the Great Salt Lake Basin

By A. D. Hess, Ph.D.
Chief, Disease Ecology Section
Public Health Service

For many years the U. S. Public Health Service has had a direct interest and responsibility in vector problems associated with the nation's water resource development program. A long-needed mechanism for coordinating this interest with related interests of other Federal agencies was provided in 1961 by the establishment of the Subcommittee on Vector Control of the Interagency Committee on Water Resources (Simmons, 1962). The primary function of this Subcommittee is to develop and recommend continuing procedures to coordinate agency activities pertaining to the prevention or control of mosquitoes and other arthropod vectors associated with water resource developments. More specifically this includes (1) actions to provide for improved cooperative research studies and demonstrations, (2) exchanging information on significant research findings, and (3) developing technical guides, standards, and educational aids in furthering a coordinated attack on the prevention and control of vectors associated with water resource developments.

One of the initial actions of the Subcommittee on Vector Control was to establish a Task Force on Cooperative Research. Under the leadership of this task force, ten interagency cooperative research projects have been initiated in various parts of the United States. One of the most successful of these has been Project V, "Development of Multi-purpose Management Techniques for Reusable Water in the Great Salt Lake Basin." This project has demonstrated the practicality of coordinating the diverse interests of agriculture, public health, wildlife conservation, and other interests relating to water resources. It also provides an outstanding example of the modern philosophy of multiple use of our natural resources. The successful activation of this project would not have been possible without the support of a Public Health Service research grant, which provides the nucleus for the cooperative investigations.

The annual reports on this project indicate that real progress has been made toward the primary objective of developing multi-purpose management techniques for reusable water. The accomplishments during the next few years should be even more impressive. The development of improved physical structures, shoreline modifications, and water management schedules in waterfowl areas will mutually benefit mosquito prevention and waterfowl conservation. With the installation of the bypass structure at Farmington Bay it will be possible to intensify the study of water level management in this important waterfowl refuge area.

The coordinated development of land preparation and irrigation systems being carried out by the Wheeler Machinery Company provides a unique opportunity to study the other important aspect of multi-purpose water use, namely the interrelationships between agricultural soil and water management practices and mosquito production.

The significance of this cooperative research project extends far beyond the Great Salt Lake Basin. It will serve as a valuable demonstration of multi-purpose management techniques for many other areas throughout the nation.

For maximum benefits, projects of this type must be carried out on a long-term basis. It is very desirable, therefore, that the studies be continued over a period of years, and that the public health, agriculture, wildlife, and other groups maintain their participation. The staff of the Disease Ecology Section, CDC, will continue to support the project by providing technical consultation on the public health aspects, and by maintaining sentinel flocks and testing their sera in order to measure levels of arbovirus activity in the study area.

Reference

Simmons, S. W. 1962. Organization and Activities of the Subcommittee on Vector Control of the Inter-agency Committee on Water Resources. Mosq. News 22(2):73-75.

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Bureau of Reclamation Report

By L. G. Moore

The Weber Basin Project now under construction in northern Utah will play an important part in the proposed program for the multi-purpose management of reusable waste waters presently entering the Great Salt Lake.

While the project is being constructed primarily to develop additional irrigation, municipal and industrial water supplies from present surpluses in the Weber River System, the benefits of the project will be felt by many in addition to those who subscribe for project water.

Control of stream flows through construction of new dams and reservoirs will prevent floods, provide improved fishing, add wildlife habitat and provide recreation possibilities. Other benefits, not so readily apparent, will also accrue to the lower-lying areas along the Great Salt Lake.

The project will drain, re-claim and supply project water to many of the present high water table lands adjacent to the Great Salt Lake. In order to insure the continued productivity of these lower-lying lands, a system of project relief and outlet drains will be built.

These drains will also serve to collect and concentrate present scattered surface wastes entering the Great Salt Lake. Thus concentrated such flows, together with the drainage waters, can be beneficially used or disposed of properly. Potential uses of such waters include irrigation, wildlife propagation and industrial.

Another important benefit to the area from the Weber Basin Project drains will be elimination of much of the mosquito problem by concentrating and properly disposing of present waste flows and elimination of mosquito breeding areas in present high water table lands and along the lake shore.

During the development of the lower-lying lands along the shores of the Great Salt Lake, the Bureau of Reclamation will cooperate with other agencies to see that every effort is made to properly manage the reusable water presently wasting to the Great Salt Lake. In the Farmington Bay area plans are proceeding with the cooperative establishment of an outlet drain with the above objective in mind.

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Marsh Management and the Study of Multi-purpose Management of Reusable Waters

By Donald A. Smith
Assistant Chief, Game Waterfowl
Utah State Department of Fish and Game

Use of water by the Utah State Department of Fish and Game for waterfowl management purposes has been a common practice for over 40 years. Many private clubs have beneficially applied water to create and maintain marsh habitat since prior to 1900. Such use, in itself, is not an issue so far as the study of multi-purpose management of water is concerned. What is of concern, from our standpoint, is how available water can be applied to provide the maximum benefits to waterfowl yet minimize production of pest insects.

Many of our developments are on the "end of the ditch" -- we are the terminal user. Thus, our water supply is controlled to a great extent by users situated along the system above us. The volume of flow we receive is variable as is the quality.

The Department is a strong advocate of the multiple use concept in management of renewable natural resources. Water is no exception. It should be used and reused to the fullest extent practical. How this can be accomplished is of concern to all the cooperators of these investigations.

A cooperative and well coordinated approach is essential if we are to recognize existing and future uses and if we are to properly integrate those needs. Some questions relative to the quality and quantity of water required to manage a specific unit of marsh habitat are being answered through cooperative research projects involving the Department and the Engineering Experiment Station and Cooperative Wildlife Research Unit of Utah State University. Several other questions confronting us can be answered through investigations being conducted under this project providing the following points are kept in mind: (1) our water needs are not static throughout the year; (2) both water quality and quantity are important in our program; (3) nearly any use we make of water will be of some benefit to waterfowl; (4) our use of water during summer, mosquito-producing months can significantly affect waterfowl at other periods of the year as well; (5) our water supplies are generally subject to legitimate alteration by other users; and (6) water use can create a serious waterfowl disease potential.

We are frequently asked, "How much water do you need to operate a waterfowl marsh?" Our answer, which appears facetious, has been, "All we can get!" There are limits to the quantity of water which can be beneficially used on a given land area. In many cases, however, we do not have a specific volume of land, but have available for our use vast expanses of land which can be seasonally flooded to provide waterfowl resting and brooding areas as well as large quantities of food.

On marshes where the land area is more definite, i. e. the marsh does not adjoin lakebed (Great Salt Lake) lands, we have attempted to acquire enough property to utilize even the high spring and fall flows of water. Occasionally, under these circumstances, we have flows which periodically exceed our needs. Such excesses are generally of short duration.

Since we develop on the basis of summer flows, and because this is generally the period of shortest supply, we have water during other periods which appears in excess of our needs. In some instances this is true, but in most cases we utilize these flows to benefit waterfowl. There is more to our marshes than the diked area -- periodically flooded areas are also essential. These are the areas receiving seasonally high flows, and which provide significant quantities of food for use by migrating waterfowl. The abundance of food and resting habitat thus created determines, to a great extent, the quality of our hunting season.

To create as much of such habitat as possible it is necessary to utilize spring and fall water supplies as late and as early as possible. In some instances this use could coincide with the mosquito production season; however, areas so managed are generally distant from population centers, or, in most cases, from individual rural dwellings. Problems created by this phase of our marsh management program should never be too serious.

Our waterfowl management areas were created, and are managed, with two primary purposes in mind: waterfowl production, and waterfowl hunting. To successfully accomplish the first of these two particular goals it is essential that we maintain as near static water levels as possible during the nesting season. This type of water management is also in the best interest of pest insect control. We are continually increasing our ability to minimize water level fluctuations through both mechanical improvements in the system and by increasing our knowledge of water delivery patterns and marsh requirements.

Intensely managed (diked) portions of our developments are designed on the basis of average flows available during the critical vegetation and waterfowl production period -- summer. During this period we generally have reasonable control over the water supply. As a rule of thumb, we calculate that 100 acres can be flooded or irrigated with each cubic foot per second of flow, providing such water is of fair quality. Quality, as we are primarily concerned with it, refers to salinity; however, organic pollution is not uncommon and must also be taken into account.

Salinity holds the same significance in our marsh management program that it does in agriculture. Soils of our marshes are highly saline. It is necessary to leach salts from the root zone for plants to become established. The time required for this leaching and the extent to which it can actually be accomplished is as much a factor of water quality as it is total supply.

Sewage effluents are useful providing they can be diluted with other flows. The dilution required depends upon the extent of treatment. Effluents high in organic wastes create serious management problems and aesthetically are highly undesirable. Such "rich" waters create conditions favorable for establishment of dense, almost impenetrable growths of aquatic vegetation. These areas are of very limited value to waterfowl.

Higher quality effluents are useful in our program and are completely depended upon for sustaining flows to some marshes during some periods. Water quality is difficult, almost impossible, for us to control.

Botulism was once the scourge of the Great Salt Lake marshes. Installation of dikes and water control structures has greatly reduced the incidence of this malady. Dormant, stagnating waters high in decaying organic material appear to create conditions most favorable for toxin production by the botulinum bacteria. Any changes in our use of water, especially during the months of August, September and early October, must be tempered by a knowledge of the influence water use has in controlling or creating conditions for botulism.

Water, in our arid State of Utah, is a valuable item. Its use affects all of us. Greater beneficial use can be made if all users understand and respect the rights and uses of others. The study of multi-purpose management of reusable water is a vital initial step in realizing the full potential of water along the Wasatch Front area.

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Current Activities of State Engineer's Office On Lower Jordan River

By Wayne D. Criddle
Utah State Engineer

The State Engineer is charged by law with responsibility for the establishment and adjudication of water rights and under certain conditions with the distribution of available supplies. In recent years, several requests have been made by organizations using water from the Lower Jordan River (that portion of the river north of 21st South Street including the Surplus Canal) for the office to assume some control over deliveries of water. Following meetings with the affected parties, we have proposed a temporary basis for the division of water at 21st South Street. However, it now appears that the proposal is not acceptable to all concerned.

In an effort to arrive at a sound basis for future water deliveries, we are presently making surveys for the purpose of preparing a determination of existing rights. Through these surveys we are attempting to locate all points at which water is diverted from this section of the river system and to identify the lands or other uses served.

The field work is conducted with the use of aerial photos to the scale of one-inch equals 500 feet. Trips have been made by boat down the Jordan River and Surplus Canal in an attempt to locate all diversion points and then mark them on the photos. These are later visited and the ditch system and lands served are sketched on the photo. Maps will be prepared on which the property ownerships will be related to the uses of water.

Once all the factual data has been gathered, searches will be made of information available in the State Engineer's Office including any claims or applications which may have been filed. County courthouse records will also be searched to obtain all available information.

Meetings will be scheduled with each property owner for the purpose of preparing water user claims covering their water rights. Based upon these claims, the State Engineer will then prepare a proposed determination of water rights which will be submitted to the District Court.

It may be possible to gain court recognition of an interlocutory distribution schedule without the necessity of first completing the final determination of rights. This could serve as a basis for the distribution of available supplies until the court may order some modification. After such a schedule has been adopted, a water commissioner, or commissioners, can be appointed to administer and deliver the available supplies.

In the preparation of a water right determination for this area, several items of a somewhat controversial nature will be evaluated and established by the court. Among these are the following:

1. Is use of water for creating marsh areas for waterfowl a beneficial use?
2. In the interest of the public, should restrictions be placed on the quantities and periods during which water may enter the marsh areas for mosquito control?
3. What is the normal season of use of water for the waterfowl area?
4. What is the normal irrigation season for the various agricultural crops?
5. What is the annual water requirement of the agricultural lands and waterfowl areas?
6. How should the water of the Jordan River be administered at the head of the Surplus Canal for flood control purposes?
7. What control and administration should be placed on the river to prevent use of water by those parties who hold no water rights?

The office will need the assistance of all affected parties if proper solutions to these complex problems are to be had. In an effort to obtain the opinion of experts on some of these questions, arrangements were made with the Agricultural Research Service of the U.S.D.A. to have one of their top men prepare a report on water requirements of the area. Mr. Karl Harris of Phoenix spent the month of August, 1964, in Salt Lake, during which time he personally visited the area, examined available data and discussed aspects of the problem with representatives of various affected agencies. A report of his findings and recommendations is presently being prepared.

In addition to these activities, the State Engineer cooperates with the Federal Government and other agencies in the basic data gathering program of the U. S. Geological Survey. He is also participating in the current comprehensive water supply study of Salt Lake County under the leadership of that agency.

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Water Resource Study in Salt Lake County *

By W. V. Iorns, Hydrologist
U. S. Geological Survey

In December 1961, the State Engineer for Utah called a meeting of water users and those interested in, and responsible for, water development in Salt Lake County. The purpose of the meeting was to discuss the immediate and future water problems facing the people of Salt Lake County and to consider means of meeting them.

An investigation of water resources of Salt Lake County was undertaken by the Water Resources Division of the U. S. Geological Survey in July, 1963. This is a cooperative project financed equally by the State of Utah and the federal government in accordance with a cooperative agreement between the State Engineer and the Geological Survey. The Utah Water and Power Board, Utah Fish and Game Commission, Salt Lake County Water Conservancy District, Metropolitan Water District of Salt Lake City, Salt Lake County, Kennecott Copper Corporation, Utah Power and Light Company, and Salt Lake Chamber of Commerce are contributing funds to the office of the State Engineer toward the support of the project, which is planned to last about six years — the first five years will be principally for data collection and data analysis and the last year for report preparation.

Those responsible for water management, to make sound decisions regarding water development, use, control, treatment, conservation and law, must have as complete information as possible of the behavior and characteristics of the surface and ground waters of the county. The following questions illustrate the information needed:

1. How much water is available from local sources for use now and in the future? Is the available water suitable for the varied uses, or must extensive treatment be employed for some uses?

2. What part of the available ground water supply has been developed? Has development caused the quality of the water to deteriorate?

3. Is artificial recharge a possible solution to the problem of declining ground water levels? If so, where and how might artificial recharge be accomplished? How much water might be stored for future use by this means? Will its suitability for use be greater or less than surface water supplies? Should lands for recharge areas be zoned at an early date?

4. How much water is being discharged into Great Salt Lake? Can part of this water be salvaged for use? Is it suitable for municipal, industrial, agricultural, recreational, or wildlife use?

5. Will further development of ground water resources cause intrustion of brine from the lake? Can manipulation of discharges of water from wells deter possible intrustion?

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* Extracted from paper presented at Seventeenth Annual Meeting of Utah Mosquito Abatement Association.

6. How much water can be stored at different potential storage sites in the county?

7. Have changes in land use caused changes in run-off, sediment production, or water quality?

8. How serious are flood threats along the various watercourses? With what frequency and magnitude may floods be expected?

9. Should some drainage channels and floodplains be zoned for restricted use?

10. How much water, if any, will need to be imported from outside sources to meet future demands?

We in the Geological Survey, particularly those who are actively engaged on this project, wish to cooperate in every way possible with those responsible for water development and management in the county.

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Enough Water to Float a Duck

By J. B. Low
Leader, Utah Cooperative Wildlife Research Unit
Fish and Wildlife Service

The significance of wetlands is brought sharply into focus when it is realized that they once totaled over 127,000,000 acres in the United States, and that they have dwindled through drainage, drought and water demands to less than 75,000,000 (Shaw, 1956). Utah still has a valuable wetland resource estimated at about 1,174,000 acres. These lands are increased by the addition of 157,861 acres of marshlands developed specifically for the propagation, protection and utilization of waterfowl and related aquatic wildlife. Of these lands, 61,815 acres are under State ownership, and 96,046 acres are under Federal jurisdiction. Utah ranks second among western states in the amount of wetlands available for waterfowl and wetland wildlife.

Utah, with its many attractive wetlands, not only supports several million waterfowl and other water birds during the late summer and fall, but also produces annually not less than 225,000 ducks and geese (Smith, 1963). Our marshlands are of great value as recreational areas where many thousands of people go each year to see, photograph and study the living organisms of a marsh. Annually, 25,000 hunters seek opportunities to harvest some of the 27 different duck species and 10 species of geese and swans that are found here. Fishing also offers recreation to many hundreds of people yearly on our wetlands.

Some of the marshlands also produce mosquitoes, often annoying and pestering the urbanites who, over the past few years, have moved ever closer to the marshlands. Toxic substances such as detergents from the housewives' laundry, excessive salinity levels as a result of decreasing water supplies, or insecticides used against mosquitoes have added to the problems of producing healthy plants and animals in marsh environments. Agriculture and industry are taking ever increasing amounts of water that previously made the marshlands productive. To add to the dilemma, surplus water returned to the marsh from irrigating systems is frequently heavily laden with dissolved salts which are toxic to both plant and animal life.

Thus, studies must be made to determine better techniques and methods of using water now available for marshlands. One such a study is entitled "Development of Techniques for Multi-purpose Management of Reusable Water Before it Enters the Great Salt Lake," conducted by the University of Utah in cooperation with other State and Federal agencies.

Cooperative Efforts Needed

With an investment of several million dollars in federally owned waterfowl management areas (refuges) affected by these problems, it is logical and imperative to make a cooperative approach to them. Involved are both private and public lands, developed and undeveloped. Management varies from none to highly organized and effectively operated units. Because of participation in land and water management by State and Federal agencies such as the Utah State Department of Fish and Game, Bureau of Sport Fisheries and Wildlife, Soil Conservation Service, Bureau of Land Management, Geological Survey, and State Engineer, a cooperative project is a natural one. Added to the interests of the above land and water management agencies are programs and contributions to marshland management and mosquito suppression from such groups as private gun clubs, mosquito abatement district programs, Public Health Service and the U. S. Weather Bureau. All can add their part to the answers needed as to how best to utilize existing water and how to "provide enough water to float a duck."

Benefits to the Bureau of Sport Fisheries and Wildlife from the Project

A project which has as its objectives the gathering of facts and the development of techniques for studying water quantity, water quality, plant requirements, and planting demonstrations can be of vital interest to the Bureau of Sport Fisheries and Wildlife in managing its lands. The great importance of wildlife production on marshlands points out the significance of developing and managing habitats that will produce wildlife and at the same time produce a minimum of mosquitoes.

All conclusions drawn from such studies should be field tested and developed before recommendations are given for implementation.

The importance of water to marshes has repeatedly been brought forward by the State Engineer and others interested in water development plans in Utah. In 1963 (Anonymous, 1963) a need for additional information on the importance of evapotranspiration rates of different kinds of water-loving plants was pointed out. It was estimated that phreatophytic vegetation might use as much as 2,400,000 acre feet of water annually and that salvage of only 1/3 of this amount would supply enough water to irrigate 300,000 acres of new land, or almost enough to supply annually all the municipal and industrial requirements of the entire State projected to 1980. Thus, vegetation is important in the management of wetlands and our knowledge of wetland plant ecology needs to be increased.

In addition to the project mentioned above and related to it are several studies now being carried on by the Utah Cooperative Wildlife Research Unit. To aid the present study, selected published and unpublished works on the subject are listed below:

Christiansen, J. E. 1960. Progress Report I. Water requirements for waterfowl areas near the Great Salt Lake. Jan. 20, 65 pp.

Christiansen, J. E. 1960. Progress Report II. Water requirements for waterfowl areas near the Great Salt Lake. June 1, 24 pp.

Christiansen, J. E. and J. B. Low. 1960. Progress Report III. Water requirements for waterfowl areas near the Great Salt Lake. Dec., 32 pp.

Christiansen, J. E., M. C. Tsai, Jack Keller, J. B. Low, James Teeter and Daya Kaushik. 1961. Progress Report IV. Water requirements for waterfowl areas near the Great Salt Lake. May, 65 pp.

Christiansen, J. E. and Ming Chang Tsai. 1961. Progress Report V. Water requirements for waterfowl areas near the Great Salt Lake. Nov., 35 pp.

Kaushik, D. K., J. B. Low and J. W. Teeter. 1961. Progress Report VI. Water requirements for waterfowl areas near the Great Salt Lake. Nov., 30 pp.

Christiansen, J. E. 1963. Progress Report VII. Evapotranspiration studies at Howard Slough Refuge and salinity measurements at state and federal waterfowl refuges for 1962. April, 74 pp.

Christiansen, J. E. 1964. Evapotranspiration studies at Howard Slough Refuge and salinity measurements at all state and federal waterfowl refuges for 1963. Progress Report VIII. Feb., 20 pp.

Kaushik, D. K. 1963. The influence of salinity on the growth and reproduction of marsh plants. Ph.D. dissertation. Utah State Univ. Library. 123 pp.

Lee, E-chiang. 1964. Consumptive use of water at Howard Slough Refuge in 1962. M.S. thesis, Utah State Univ. Library. 91 pp.

Teeter, J. W. 1963. The influence of sodium chloride on the growth and reproduction of the sago pondweed (*Potamogeton pectinatus* L.). M.S. thesis, Utah State Univ. Library. 73 pp.

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Tsai, Ming-Chang. 1962. Water consumptive use studies at Howard Slough Refuge, Weber County, Utah. M.S. thesis, Utah State Univ. Library, 55 pp.

Possible Contribution of the Bureau of Sport Fisheries and Wildlife to the Multi-purpose Project

The Bureau of Sport Fisheries and Wildlife has a large staff of waterfowl and wetland specialists working on various field research areas. These, coupled with specialists on the staff of the Division of Wildlife Research at Washington, D. C., can be of assistance in consultation and review of the project outlines and reports. Flyway representatives who coordinate the many waterfowl activities of the State and Federal agencies are also a source of information on waterfowl needs and relationships. Lastly, the leaders of the Cooperative Wildlife Research Units at the Utah State University and 17 other land grant institutions can be of immediate assistance in helping direct the phases of the project dealing with wildlife, plant and water management. Managers at the three Federally owned refuges in the State would, from long years of experience, be able to evaluate critically techniques developed through the study.

Through the years the Utah Cooperative Wildlife Research Unit has carried out a substantial amount of waterfowl and marshland research. The results of these studies are available in published form from the Utah Unit, or in unpublished theses and dissertations at Utah State University. The investigations deal with such related subjects as water requirements, water quality, productivity of wildlife food and cover plant requirements, hunting and population data, population studies, and behavioral aspects of waterfowl biology, carp-waterfowl relationships, livestock-waterfowl relationships, and many other water-oriented studies. Of special interest is the subject of the Mosquito Control-Fish and Wildlife Management Committee functioning since 1962. This committee has served to increase interest in both mosquito control and wildlife management by inducing both sides to recognize the problem and seek possible solutions.

In another program titled "Water Requirements of Waterfowl Areas Near the Great Salt Lake," quantity and quality of water required by waterfowl in the State have been investigated. The basic premise upon which this research is being conducted is to supply the State Engineer with factual information on the quality of water so that it can be allocated properly for important wildlife areas. Allocations to wildlife areas are important because the water resources of Utah are rapidly being developed for agriculture and industry. This study was begun in 1960 through the cooperation of the Utah State Department of Fish and Game, the Engineering Experiment Station at the Utah State University, and the Utah Cooperative Wildlife Research Unit, and has worked on two phases of the subject: (1) the actual water required (quantity) to operate efficiently a marshland, and (2) the quality of water needed to propagate the desirable marsh and aquatic plants needed as food and cover by waterfowl. The study area selected was the relatively small 700-acre State tract known as Howard Slough Waterfowl Management Area.

Progress to date has shown that, as expected, different quantities of water are required at different seasons of the year. For example, net water used in July at Howard Slough amounted to 9.16 inches, as compared to 5.54 inches in May, when the growing season started. Use of water increased from 4.34 inches in April to the high in July, and then receded to 1.00 inch in November, for a total seasonal requirement of 43.17 inches on the marsh. Actual quantity of water required to efficiently operate this marsh will be given in a completion report. Other factors considered were evapotranspiration losses, precipitation, and ground-water contribution (Tsai, 1962 and Lee, 1964).

Important among conclusions on the quality phase of this project was that water with salinity content too high for agricultural purposes could in most instances be advantageously used on marshlands. Most waters draining from agricultural lands are salt laden but often not above the level that would have a detrimental effect on desirable food and cover plants. It was demonstrated that sago pondweed (an important food plant for ducks in Utah) was stimulated in production and growth of tubers by salinity levels of 3,000 ppm. Saline concentrations in the range of 3,000 to 3,500 ppm., those normally found on Utah marshlands, did not seriously affect germination or growth of sago pondweed (Teeter, 1963). During years of normal moisture and average use of water by agriculture and industry, the salinity of water in Utah marshes is within the tolerance range of seed germination, growth, and seed production of experimental plants (Kaushik, 1963). It should be pointed out, however, that water in the developed marshes must be maintained at desirable salinity levels by addition of water throughout the season to replace that lost by evapotranspiration.

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Lake Front Gun Club
Field Trial Planting, June, 1964

By James M. Gatherum
Unit Conservationist
Soil Conservation Service

A small field trial planting procedure was developed by the Soil Conservation Service in cooperation with collaborating agencies and the personnel engaged in research under Research Grant WP-00027.

The project of approximately one acre was carried out on a small island located immediately northeast of the club house. The soil in this area is a Leland silt clay loam with a strongly salt and alkali affected subsoil. This soil occurs on the elevated areas and is not subject to flooding. Although it is considered one of the better soils on the Lake Front Gun Club property, it is still poorly suited for growing wildlife feed. Coupled with poor quality water, the success of such a project would be very difficult.

The purpose of the plantings was to determine if wild millet (Echinochloa crusgalli) is sufficiently salt tolerant to be grown successfully for waterfowl feed under the saline conditions existing in vast areas on the Jordan River delta adjacent to Great Salt Lake.

The site was prepared by leveling the land and the construction of border dikes on the contour at 50-foot intervals. Millet seed was broadcast with a cyclone seeder on the basins at the rate of 25 pounds per acre. The border dikes were seeded with tall wheat grass (10# per acre), and yellow sweet clover (2# per acre). All seedings were raked in by volunteer boy scout assistance. Nitrogen fertilizer was applied at a rate of 30 pounds per acre. A pump was installed for pumping irrigation water.

Evaluation:

Shortly after the wild millet seed was planted, the pumping plant failed. Germination and plant emergence was poor due to the lack of irrigation water. However, in a few isolated low spots where additional water accumulated, several millet plants with a deep green color made good growth. This would indicate that with proper irrigation water management, maturity of the wild millet could be expected.

The experiment will be continued. Problems will be corrected and operation adjustments made with the desire of establishing a satisfactory stand of vegetation for wildlife feed and habitat on these sites.

North Point Gun Club
Field Trial Planting, June, 1964

By James M. Gatherum
Unit Conservationist
Soil Conservation Service

A small field trial planting procedure was developed by the Soil Conservation Service in cooperation with representatives of the North Point Gun Club.

The project of approximately eight acres was carried out on an area designated as Site #1, north of the club headquarters. The plantings were made on Jordan silty clay loam soil. This is a deep, brown soil with a very strong salt and alkali affected subsoil. Plants must be salt and alkali tolerant to grow under these conditions. The Jordan soils occur on the elevated areas and are not subject to flooding.

The purpose of the plantings was to determine if Japanese millet (Echinochloa crusgalli var. frumentacea) is sufficiently salt tolerant to be grown successfully for waterfowl feed under the saline conditions existing in vast areas on the Jordan River delta adjacent to Great Salt Lake.

The site was prepared by leveling the land, and construction of border dikes on the contour at 50-foot intervals. This made a series of level basins. About July 1, Japanese millet seed was planted at the rate of 25 pounds per acre. The border dikes were seeded with tall wheat grass (10# per acre) and yellow sweet clover (2# per acre). A small canal was dug and a pumping plant set up for irrigation purposes. Structures were installed in the border dikes for water control. The area was fenced to exclude livestock. Nitrogen was applied at the rate of 30 pounds per acre. Plant emergence was good with the establishment of dense stands in the basins. Seedling growth within the basins continued normally for only a short time after which the plants turned a brownish-yellow color and stopped growing. The plants above the waterline on the border dikes continued to grow, stooled out, and matured abundant seed heads.

Evaluation:

1. Seeding time was too late in the growing season for good plant growth. Earlier plantings should give better results as the weather will not be so warm.

2. The rate of seeding resulted in a stand too dense for proper stooling out and seedhead development. A reduction to 10 to 15 pounds per acre should make better growth and maturity conditions.

3. The smooth, flat basins without corrugations allowed excess water to stand around the plants causing scalding. Deep corrugations (6 inches deep) in the basins should alleviate this problem.

4. The rougher and cloddier the seedbed the better the plant growth should be.

5. Light, frequent irrigations, care being taken not to overtop the furrows should prevent scalding of the plants and induce maximum plant growth.

6. Both ducks and pheasants frequented the area. Based on a report made by Mr. Diets of the State Fish and Game Department, waterfowl take the seed very readily.

7. The experiment was sufficiently successful that it will be continued. Problems will be corrected and operation adjustments made with the desire of establishing a satisfactory stand of vegetation for wildlife feed and habitat on these sites.

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